The Parliament of the Commonwealth of Australia

Australia's uranium — Greenhouse friendly fuel for an energy hungry world

A case study into the strategic importance of Australia's uranium resources for the Inquiry into developing Australia's non-fossil fuel energy industry

House of Representatives
Standing Committee on Industry and Resources

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Cover photographs:

- Drums of uranium oxide concentrate (hydrated uranium peroxide) at the Beverley uranium mine, South Australia. Photograph courtesy of Heathgate Resources Pty Ltd
- Olympic Dam, South Australia (right top). Photograph courtesy of BHP Billiton Ltd
- Ranger, Northern Territory (right bottom). Photograph courtesy of Energy Resources of Australia Ltd

Cover design: Ms Lisa McDonald, Department of the House of Representatives

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Foreword

The Committee's inquiry commenced in March 2005, when there was little mention in Australia of uranium mining and even less of nuclear power's much predicted global expansion. Throughout the course of the Inquiry the Committee noted a significant shift in the debate in relation to nuclear power, driven by community concerns about greenhouse gas emissions and climate change. This shift was reflected at the federal level with the establishment in August 2005 of a Steering Group to develop a Uranium Industry Framework and, in June 2006, with the Prime Minister's Taskforce commissioned to review uranium mining, processing and nuclear energy in Australia.

There is now a growing recognition that nuclear power makes a significant contribution to the mitigation of greenhouse gas emissions. Worldwide, nuclear power plants currently save some 10 per cent of total carbon dioxide (CO_2) emissions from world energy use. This represents an immense saving of greenhouse gas emissions that would otherwise be contributing to global warming. If the world were not using nuclear power, emissions of CO_2 would be some 2.5 billion tonnes higher per year.

Nuclear power plants emit no greenhouse gas emissions at point of generation and very small quantities over the whole nuclear fuel cycle, from uranium mining through to waste disposal. Indeed, the Committee reports that nuclear power emits only 2 to 6 grams of carbon per kilowatt hour of electricity produced. This is two orders of magnitude less than coal, oil and natural gas, and is comparable to emissions from wind and solar power.

A single nuclear power plant of one gigawatt capacity offsets the emission of some 7–8 million tonnes of CO_2 each year, if it displaces use of coal. Nuclear power also avoids the emission of sulphur dioxide, nitrous oxide and particulates, thereby significantly contributing to air quality.

Australia's uranium exports displace some 395 million tonnes of CO_2 each year, relative to black coal electricity generation, and this represents some 70 per cent of Australia's total greenhouse gas emissions for 2003.

Nuclear power represents the only current reliable and proven means of limiting increased emissions while meeting the world's voracious appetite for energy. While the Committee recognises that there is a role for renewables and certainly for greater use of efficiency measures, renewables are limited in their application by being intermittent, diffuse and pose significant energy storage problems. Renewables also require substantial backup generation, which needs to be provided by conventional baseload power sources. Promised baseload contributions from geothermal, which will be welcome, are yet to be developed on any scale. For the generation of continuous, reliable supplies of electricity on a large scale, the only current alternative to fossil fuels is nuclear power.

Naturally, the Committee welcomes the contribution that renewables and energy efficiency measures can make to greenhouse gas mitigation, but these measures alone have no prospect whatsoever of meeting rapidly growing demands for energy and abating greenhouse gas missions to the degree required. There is a clear need for a mix of low-emission energy sources and technologies, in which nuclear power will continue to play a vital part.

The Committee believes that the 'nuclear versus renewables' dichotomy is a false debate and misses the point: while renewables have a contribution to make, other than hydro and potentially geothermal and novel combinations of existing technologies, they are simply not capable of providing baseload power on a large scale. The relevant comparison, if one needs to be made, is between baseload alternatives. On this issue the evidence is absolutely clear—nuclear power is the only proven technology for baseload power supply that does not release substantial amounts of CO_2.

The Committee also recognises that, given its comparative advantage in fossil fuels and the world's projected continued reliance on these fuels, Australia has a strong economic interest in supporting technologies that reduce the greenhouse intensity of fossil fuel use. The Committee therefore agrees that nuclear power should not be seen as competing with or substituting for clean- coal technologies, and indeed for renewables such as photovoltaics in which Australia has expertise.

No-one asserted to the Committee during the course of the inquiry that nuclear power alone can 'solve' climate change. Being restricted at the present time to the generation of electricity, nuclear energy obviously cannot reduce emissions from all sectors, although nuclear power does have the potential to reduce emissions in the transport sector through the production of hydrogen. However, electricity generation, which is already the largest contributor of CO_2 emissions at 40 per cent of the global total, is also the fastest growing. It is imperative that emissions from this sector be reduced, particularly in fast growing developing nations such as China.

In view of the projected growth in energy demand and the imperative for large developing nations to reduce their reliance on fossil fuels, the Committee believes that, with its immense endowment of uranium, Australia is uniquely placed to make a significant contribution to emissions reductions through increased production and supply of uranium. The Committee wholeheartedly agrees with a submitter who stated that through its supply of uranium 'Australia should throw the world a climate lifeline.'

The Committee recognised from the outset of the inquiry that, in coming to a considered view about the possible expansion of uranium mining in Australia, the Committee needed to examine the three key issues associated with uranium mining and use of nuclear power which some submitters claim are 'unresolved'. These issues relate to the: generation and management of radioactive waste across the nuclear fuel cycle; safety of the fuel cycle, particularly the operation of nuclear reactors and the risks to health from fuel cycle industries, including uranium mining; and the risk of proliferation of nuclear materials and technologies, and their diversion for use in weapons programs. The Committee's report comprehensively addresses each of these issues.

The Committee does not question the sincerity with which those people expressing 'moral outrage' at the very existence of the uranium industry hold their views. However, the Committee believes that these views are not informed by an accurate assessment of the benefits and risks associated with the industry and from use of nuclear power.

Negative public perceptions of the uranium industry, misconceptions about the nature of the industry's operations on the issues of waste, safety and proliferation, combined with political timidity, have clearly impeded the uranium industry's growth and Australia's involvement in the nuclear fuel cycle over several decades. There have, for example, been several missed opportunities for Australia to add value to its resources by processing uranium domestically prior to export.

It is notable that on such an historically controversial subject as uranium mining and exports the Committee has produced a unanimous report. All members are agreed that the present restrictions on uranium exploration and mining are illogical, inconsistent and anti-competitive. Restrictions have impeded investment in the industry, and have resulted in a loss of regional employment and wealth creation opportunities, royalties and taxation receipts. The only beneficiaries of restrictions are the existing producers and foreign competitors. The Committee concludes that state policies preventing development of new uranium mines should be lifted and legislative restrictions on uranium mining should be repealed.

Uranium is Australia's second largest energy export in terms of contained energy content. Uranium is an immensely concentrated source of energy—one tonne of uranium oxide generates the same amount of energy as 20 000 tonnes of black coal. The uranium produced from just one of Australia's mines each year—Ranger, in the Northern Territory—contains sufficient energy to provide for 80 per cent of Australia's total annual electricity requirements, or all of Taiwan's electricity needs for a year.

However, while Australia is well endowed with energy resources for its own needs, other countries are not so fortunate. These include developing countries such as China. As a matter of energy justice, Australia should not deny countries who wish to use nuclear power in a responsible manner the benefits from doing so. Neither should Australia refuse to export its uranium to assist in addressing the global energy imbalance and the disparity in living standards associated with this global inequity.

Finally, in turning from a past in which Australia has consistently missed opportunities to add value to its uranium resources, a majority of the Committee concludes that the federal and state governments should now prepare for the possible establishment of other fuel cycle industries in Australia by: examining how value-adding could occur domestically while meeting non-proliferation objectives; developing an appropriate licensing and regulatory framework; and rebuilding Australia's nuclear skills base and expertise.

On behalf of the Committee, I thank the three companies that facilitated the Committee's inspections of the currently operating uranium mines—BHP Billiton Ltd, Energy Resources of Australia Ltd and Heathgate Resources Pty Ltd.

Finally, I wish to thank my Committee colleagues who participated keenly throughout the Inquiry. In particular, I wish to express my sincere thanks to the members of the Committee from the Opposition, whose enthusiasm and spirit of bipartisanship for this important and historic inquiry was admirable.

The Hon Geoff Prosser MP
Chairman

Membership of the Committee

Chairman	The Hon Geoff Prosser MP
Deputy Chair	Mr Michael Hatton MP
Members	The Hon Dick Adams MP
	The Hon Bronwyn Bishop MP
	The Hon Alan Cadman MP
	Mr Martin Ferguson MP
	Mr Barry Haase MP
	The Hon Robert Katter MP
	The Hon Jackie Kelly MP
	Mr David Tollner MP

Committee Secretariat

Secretary	Mr Russell Chafer
Inquiry Secretary	Mr Jerome Brown
Research Officers	Mr Muzammil Ali (until December 2005)
	Ms Peggy Danaee (from January 2006 until October 2006)
Administration Officer	Ms Penelope Humphries

Terms of reference

On 15 March 2005 the Minister for Industry, Tourism and Resources, the Hon Ian Macfarlane MP, referred the following inquiry to the Committee.

The House of Representatives Standing Committee on Industry and Resources shall inquire into and report on the development of the non-fossil fuel energy industry in Australia.

The Committee shall commence its inquiry with a case study into the strategic importance of Australia's uranium resources. The case study shall have particular regard to the:

a) global demand for Australia's uranium resources and associated supply issues;

b) strategic importance of Australia's uranium resources and any relevant industry developments;

c) potential implications for global greenhouse gas emission reductions from the further development and export of Australia's uranium resources; and

d) current structure and regulatory environment of the uranium mining sector (noting the work that has been undertaken by other inquiries and reviews on these issues).

Additional issues

1. Whole of life cycle waste management assessment of the uranium industry, including radioactive waste management at mine sites in Australia, and nuclear waste management overseas consequent to use of Australian exported uranium.

2. The adequacy of social impact assessment, consultation and approval processes with traditional owners and affected Aboriginal people in relation to uranium mining resource projects.

3. Examination of health risks to workers and to the public from exposure to ionising radiation from uranium mining.

4. Adequacy of regulation of uranium mining by the Commonwealth.

5. Assessing the extent of federal subsidies, rebates and other mechanisms used to facilitate uranium mining and resource development.

6. The effectiveness of safeguards regimes in addressing the proliferation of fissile material, the potential diversion of Australian obligate fissile materials, and the potential for Australian obligate radioactive materials to be used in 'dirty bombs'.

List of abbreviations

Acronyms

AAEC	Australian Atomic Energy Commission
ACF	Australian Conservation Foundation
ALRA	*Aboriginal Land Rights Act*
AMEC	Association of Mining and Exploration Companies
AMP CISFT	AMP Capital Investors Sustainable Funds Team
ANA	Australian Nuclear Association
ANF	Australian Nuclear Forum
ANSTO	Australian Nuclear Science and Technology Organisation
AONM	Australian Obligated Nuclear Material
AP	Additional Protocol
ARPANSA	Australian Radiation Protection and Nuclear Safety Agency
ARR	Alligator Rivers Region
ARRAC	Alligator Rivers Region Consultative Committee
ARRTC	Alligator Rivers Region Technical Committee
ASNO	Australian Safeguards and Non-Proliferation Office
ASMV	Australian Student Mineral Venture
BHPB	BHP Billiton Ltd
BSS	International Basic Safety Standards for Protection against Ionising Radiation and for the Safety of Radiation Sources

CIM	Chief Inspector of Mines
COAG	Council of Australian Governments
DEH	Department of the Environment and Heritage
DITR	Australian Government Department of Industry, Tourism and Resources
DPIFM	Northern Territory Department of Primary Industry, Fisheries and Mines
ECNT	Environment Centre of the Northern Territory
EDR	Economic Demonstrated Resources
EIA	Environmental Impact Assessment
EPA	Environmental Protection Authority
EPBC	*Environment Protection and Biodiversity Conservation Act 1999*
EPIP	*Environment Protection (Impact of Proposals) Act 1974*
ERA	Energy Resources of Australia Ltd
ERISS	Environmental Research Institute of the Supervising Scientist
FOE	Friends of the Earth–Australia
GA	Geoscience Australia
GAB	Great Artesian Basin
GAC	Gundjeihmi Aboriginal Corporation
GHG	Greenhouse gas
HEU	High-enriched uranium
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IR	Inferred Resources
ISL	In-situ leaching
KBM	Kakadu Board of Management
KRSIS	Kakadu Regional Social Impact Survey

LEU	Low-enriched uranium
MAPW	Medical Association for the Prevention of War
MOX	Mixed oxide fuel
MSTC	Mine Site Technical Committee
MUF	Material Unaccounted For
NLC	Northern Land Council
NNPA	Nuclear Non-Proliferation Agreement
NNWS	Non-Nuclear weapons state(s)
NPT	*Treaty on the Non-Proliferation of Nuclear Weapons*
NRC	US Nuclear Regulatory Commission
NT	Northern Territory
NTMC	Northern Territory Minerals Council
NWS	Nuclear weapon state(s)
OSS	Office of the Supervising Scientist
PIRSA	Department of Primary Industries and Resources, South Australia
PWR	Pressurised Water Reactor
RAR	Reasonably Assured Resources
SA	South Australia
SACOME	South Australian Chamber of Mines and Energy
SIA	Submarine Institute of Australia
SSD	Supervising Scientist Division
SWU	Separative work unit
SXR	Southern Cross Resources Inc
UIC	Uranium Information Centre
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
UOC	Uranium oxide concentrate
WMD	Weapons of mass destruction

Units

Bq	becquerel
g	grams
g/t	grams per tonne
gC_{eq}/kWh	grams of carbon equivalent per kilowatt-hour
GtC	gigatonnes (billions) of carbon (emissions)
GW	gigawatt (giga = billion, 10^9 watts)
GWe / GWt	gigawatts of electrical / thermal power
kg	kilogram
kWe	kilowatts of electrical power
kWh	kilowatt-hour
m^3	cubic metres
mSv	millisievert
MtC	million tonnes of carbon (emissions)
MWe / MWt	megawatts of electrical / thermal power (mega = million, 10^6 watts)
MWh	megawatt-hour of electrical power
Mt	million tonnes
Pu-239 (or Pu^{239})	isotope 239 of plutonium
Sv	Sievert
µSv	microsievert
ppm	parts per million
ppb	parts per billion
Pu	plutonium
Pu-239 (or Pu^{239})	isotope 239 of plutonium
t	tonnes
toe	tonnes of oil equivalent

tpa	tonnes per annum
tU	tonnes of uranium
TW	terawatt (tera = trillion, 10^{12} watts)
TWa	terawatt-year
TWh	terawatt-hour
μg/L	micrograms per litre
U	uranium
U-233 (or U^{233})	isotope 233 of uranium
U-235 (or U^{235})	isotope 235 of uranium
U-238 (or U^{238})	isotope 238 of uranium
UF_6	uranium hexafluoride
UO_2	uranium dioxide
$UO_4.2H_2O$	hydrated uranium peroxide
U_3O_8	uranium oxide (triuranium octaoxide)
W	watt

Glossary[1]

Actinide	An element with atomic number of 89 (actinium) or above.
Aquifer	A permeable underground soil or rock formation capable of storing and allowing flow of water.
Australian Obligated Nuclear Material (AONM)	Australian uranium and nuclear material derived there from, which is subject to obligations pursuant to Australia's bilateral safeguards agreements.
Becquerel (Bq)	The unit of measure of actual radioactivity in material, where one Bq equals one nuclear disintegration per second.
Depleted uranium	Uranium having a U-235 content less than that found in nature (e.g. as a result of the uranium enrichment processes). Depleted uranium can be blended with highly enriched uranium (e.g. from weapons) to make reactor fuel.
Economic Demonstrated Resources (EDR)	Category from the Australian National Classification System for Identified Mineral Resources which refers to resources for which profitable extraction or production under defined investment assumptions is possible.

1 The glossary has been compiled from the following sources: OECD Nuclear Energy Agency, *Nuclear Energy Today*, OECD-NEA, Paris, 2003, pp. 91–102; Australian Safeguards and Non-Proliferation Office, *Annual Report 2003–2004*, ASNO, Canberra, 2004, pp. 143–49; Senate Environment, Communications, Information Technology and the Arts References Committee, *Regulating the Ranger, Jabiluka, Beverley and Honeymoon uranium mines*, SECITARC, Canberra, 2003, pp. 321–27; Australian Science and Technology Council, *Australia's Role in the Nuclear Fuel Cycle*, AGPS, Canberra, 1984, pp. 301–12; World Nuclear Association, *Glossary*, WNA, London, 2002, viewed 21 June 2005, <http://www.world-nuclear.org/info/inf51.htm>; Uranium Information Centre, *Glossary: Nuclear Issues Briefing Paper 30*, UIC, Melbourne, 2002, viewed 21 June 2005, <http://www.uic.com.au/nip30.htm>; OECD-NEA/International Atomic Energy Agency, *Uranium 2003: Resources, Production and Demand*, OECD-NEA/IAEA, Paris, 2004, pp. 261–77; OECD-NEA/IAEA, *Uranium 2005: Resources, Production and Demand*, OECD-NEA/IAEA, Paris, 2005, pp. 261–276. Joint Ore Reserves Committee, *The JORC Code*, AusIMM, MCA and AIG, 2004 edn; G Taylor et. al., *Review of Environmental Impacts of the Acid In-Situ Leach Uranium Mining Process*, CSIRO Land and Water, Melbourne, 2004, pp. 56–58; Geoscience Australia, *Australia's Identified Mineral Resources 2005*, GA, Canberra, 2005, p. 88; IAEA, *Analysis of Uranium Supply to 2050*, IAEA, Vienna, 2001, p.101.

Enrichment	A physical or chemical process for increasing the proportion of a particular isotope. Uranium enrichment involves increasing the proportion of U-235 from its level in natural uranium, which is 0.711%: for low enriched uranium fuel the proportion of U-235 (the enrichment level) is typically increased to between 3% and 5%. Weapons-grade uranium is more than 90% U-235.
Fertile material	A fertile material is one that is capable of becoming fissile through the capture of a neutron(s), possibly followed by radioactive decay. Important examples are U-238, which is fissionable but can also transmute into fissile Pu-239, and Th-232, which can transmute into fissile U-233.
Fissile material	Referring to a nuclide capable of undergoing fission by 'thermal' neutrons (e.g. U-233, U-235, Pu-239).
Fission	The splitting of an atomic nucleus into roughly equal parts, often by a neutron. In a fission reaction, a neutron collides with a fissile nuclide (e.g. U-235) and splits, releasing energy and new neutrons. Many of these neutrons may go on to collide with other fissile nuclei, setting up a nuclear chain reaction.
Fission fragments (or products)	When a nucleus undergoes fission, it splits into two fragments, releases neutrons and energy. The fragments are often called fission products, which may be stable or unstable, i.e. radioactive. Important fission product isotopes (in terms of their relative abundance and high radioactivity) are bromine, caesium, iodine, krypton, rubidium, strontium and xenon. They and their decay products form a significant component of nuclear waste.
Fissionable material	A fissionable material is a material that is capable of undergoing fission, normally differentiated from fissile in that these will fission if impacted by a fast neutron (e.g. U-238).
Fusion	Fusion is a nuclear reaction where light nuclei combine to form more massive nuclei with the release of energy. This process takes place continuously in the universe. In the core of the sun, at temperatures of 10–15 million

	degrees celsius, hydrogen is converted into helium, providing energy that sustains life on earth.
Highly enriched uranium (HEU)	Uranium enriched to at least 20% U-235. HEU is used principally for producing nuclear weapons and fuel for reactors to propel submarines and other vessels. Weapons grade HEU contains at least 90% U-235.
Indicated Mineral Resource	A sub-category of Mineral Resource from the JORC Code. An 'Indicated Mineral Resource' is that part of a Mineral Resource for which tonnage, densities, shape, physical characteristics, grade and mineral content can be estimated with a reasonable level of confidence. It is based on exploration, sampling and testing information gathered through appropriate techniques from locations such as outcrops, trenches, pits, workings and drill holes. The locations are too widely or inappropriately spaced to confirm geological and/or grade continuity but are spaced closely enough for continuity to be assumed.
Inferred Mineral Resource	A sub-category of Mineral Resource from the JORC Code. An 'Inferred Mineral Resource' is that part of a Mineral Resource for which tonnage, grade and mineral content can be estimated with a low level of confidence. It is inferred from geological evidence and assumed but not verified geological and/or grade continuity. It is based on information gathered through appropriate techniques from locations such as outcrops, trenches, pits, workings and drill holes which may be limited or of uncertain quality and reliability.
Inferred Resources (IR)	Category from the NEA / IAEA uranium resource classification scheme which refers to uranium, in addition to Reasonably Assured Resources (RAR), that is inferred to occur based on direct geological evidence, in extensions of well-explored deposits, or in deposits in which geological continuity has been established but where specific data are considered to be inadequate to classify the resource as RAR.
In-situ leach (ISL)	The recovery by chemical leaching of minerals from porous orebodies without physical excavation. Also known as solution mining. ISL is the mining method employed at Beverley uranium mine in South Australia.

Ionising radiation	Radiation which when absorbed causes electrons to be added or removed from atoms in absorbing matter, producing electrically charged particles called ions. This process is known as ionisation.
Isotopes	Different forms of a chemical element having the same number of protons in their atoms, but different numbers of neutrons, e.g. U-235 (92 protons and 143 neutrons) and U-238 (92 protons and 146 neutrons). The number of neutrons in an atomic nucleus, while not significantly altering its chemistry, does alter its properties in nuclear reactions.
JORC Code (or 'the Code')	The Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves, developed by the Joint Ore Reserves Committee of The Australasian Institute of Mining and Metallurgy, Australian Institute of Geoscientists and Minerals Council of Australia. The Code sets out minimum standards, recommendations and guidelines for public reporting in Australasia of exploration results, mineral resources and ore reserves. The Code has been adopted by and included in the listing rules of the Australian Stock Exchange.
Kilowatt-hour (kWh)	The kilowatt-hour (kWh) is a unit of energy equivalent to one kilowatt (1 kW = 1 000 W) of power expended for one hour of time. This equals 3.6 million joules (megajoules or MJ). The kilowatt-hour is not a standard unit in any formal system, but it is commonly used in electrical applications.
Material Unaccounted For (MUF)	A term used in nuclear materials accountancy to mean the difference between operator records and the verified physical inventory. A large MUF may indicate diversion of material or loss of control, however, a certain level of MUF is expected due to measurement processes.
Measured Mineral Resource	A sub-category of Mineral Resource from the JORC Code. A 'Measured Mineral Resource' is that part of a Mineral Resource for which tonnage, densities, shape, physical characteristics, grade and mineral content can be estimated with a high level of confidence. It is based on detailed and reliable exploration, sampling and testing information gathered through appropriate

	techniques from locations such as outcrops, trenches, pits, workings and drill holes. The locations are spaced closely enough to confirm geological and grade continuity.
Megawatt (MW)	A megawatt is the international unit of power equal to one million (10^6) watts. A megawatt electrical (MWe) refers to electrical output from a generator. A megawatt thermal (MWt) refers to the thermal (i.e. heat) output from a reactor. The difference is the measure of the efficiency of the power generation process—transforming the heat energy into electricity. Typically, the heat output of a nuclear reactor is three times its electrical output, thus a reactor with a thermal output of 2 700 MW may produce about 900 MW of electricity (i.e. around 33% efficient).
Mineral Resource	Category from the JORC Code. A 'Mineral Resource' is a concentration or occurrence of material of intrinsic economic interest in or on the Earth's crust in such form, quality and quantity that there are reasonable prospects for eventual economic extraction. The location, quantity, grade, geological characteristics and continuity of a Mineral Resource are known, estimated or interpreted from specific geological evidence and knowledge. Mineral Resources are sub-divided, in order of increasing geological confidence, into Inferred, Indicated and Measured categories.
Mixed Oxide Fuel (MOX)	A fuel fabricated from plutonium and depleted ora natural uranium oxide which can be used in standard light water rectors.
Natural uranium	Uranium with an isotopic composition found in nature, containing 99.28% U-238, 0.71% U-235 and 0.01% U-234. Can be used as fuel in heavy water-moderated nuclear reactors.
NEA / IAEA (uranium resources) classification scheme	The OECD Nuclear Energy Agency (OECD-NEA) and the International Atomic Energy Agency (IAEA) classification scheme for uranium resources. The scheme has been adopted internationally and divides resource estimates into categories that reflect the level of confidence in the quantities of recoverable uranium against the cost of production. Resources are divided

	into two major classifications of Identified and Undiscovered resources. Identified Resources are further classified into Reasonably Assured Resources (RAR) and Inferred Resources (IR). The cost categories are defined as <US$40/kgU, <US$80/kgU, and <US$130/kgU. Resource estimates in this classification scheme are expressed in terms of tonnes of recoverable uranium (rather than uranium oxide) after losses due to mining and milling have been deducted. These categories are broadly equivalent to the national classification scheme used by Geoscience Australia. For example, RAR recoverable at less than US$40/kg U is equivalent to Economic Demonstrated Resources (EDR) in the Australian classification scheme. The OECD-NEA and IAEA resource estimates are published biennially in *Uranium Resources, Production and Demand*, which is commonly known as the 'Red Book'.
Net U_3O_8	U_3O_8 contained in the UOC or uranium peroxide.
Nuclear weapon state(s) (NWS)	The five states recognised by the *Treaty on the Non-Proliferation of Nuclear Weapons* as having nuclear weapons at 1 January 1967 when the Treaty was negotiated, namely the United States, Russia, the United Kingdom, France and China.
Nuclide	Nuclear species characterised by the number of protons (atomic number) and the number of neutrons. The total number of protons and neutrons is called the mass number of the nuclide.
Nuclear (or uranium) fuel cycle	The sequence of processes, from uranium mining through to the final disposal of waste materials, associated with the production of electricity from nuclear reactions. There are two common types of fuel cycle: closed and open (or once-through) fuel cycles. The main stages in the closed fuel cycle are: mining and milling of uranium ore; conversion and enrichment of uranium; fuel fabrication; fission in a reactor for the generation of power, or production of radioisotopes (for medical, industrial or research purposes); reprocessing of the used fuel elements; and disposal and storage of wastes. The open fuel cycle excludes reprocessing.

Nuclear power reactor	A nuclear reactor produces and controls the release of energy from splitting (fissioning) the atoms of certain elements (e.g. uranium-235). The energy released is used as heat to make steam to generate electricity. The principles for using nuclear power to produce electricity are the same for most types of reactor. The energy released from continuous fission of the atoms of the fuel is harnessed as heat in either a gas or water, and is used to produce steam. The steam is used to drive the turbines which produce electricity (as in most fossil fuel plants). Several generations of nuclear reactors are commonly distinguished: Generation I reactors were developed in the 1950–60s and, outside the UK, none are still operating today; Generation II reactors are typified by the present US fleet and most elsewhere; Generation III (and III+) designs are known as 'Advanced Reactors' and are now being deployed, with the first in operation in Japan since 1996 and once each currently being built in France and Finland. Six Generation IV reactor technologies are currently being developed, with some at an advanced stage. Prior to being deployed, reactor designs must be licensed (along with the siting, construction, operations and decommissioning of each reactor) by the relevant regulatory authority (e.g. the Nuclear Regulatory Commission in the United States).
Ore	Any metalliferous mineral from which the metal may be profitably extracted. An orebody is soil or rock containing minerals of economic value.
Ore Reserve	Category from the JORC Code. An 'Ore Reserve' is the economically mineable part of a Measured and/or Indicated Mineral Resource. It includes diluting materials and allowances for losses, which may occur when the material is mined. Appropriate assessments and studies have been carried out, and include consideration of and modification by realistically assumed mining, metallurgical, economic, marketing,

	legal, environmental, social and governmental factors. These assessments demonstrate at the time of reporting that extraction could reasonably be justified. Ore Reserves are sub-divided in order of increasing confidence into Probable Ore Reserves and Proved Ore Reserves.
Overburden	Useless soil and rock which overlies a bed of useful material.
Palaeochannel	Ancient river or stream channels that have been preserved in sedimentary rocks.
pH	A measure of hydrogen ions in solution; it indicates acidity (pH 1 to 7) or alkalinity (pH 8 to 14) of an aqueous solution.
Plutonium (Pu)	A heavy, fissionable, radioactive metallic element with atomic number 94. Plutonium is not naturally occurring, but is produced as a by-product of the fission reaction in a uranium fuelled nuclear reactor and is recovered from irradiated fuel. It is used in preparing commercial nuclear fuel and in manufacturing nuclear weapons.
Radiation	The emission and propagation of energy by means of electromagnetic waves or particles.
Radiation dose	A measure of the amount of radiation absorbed by the body and the damage this radiation causes the person. This is determined by the type and energy of the radiation (alpha, beta, gamma), and the exposure scenario. Units of dose are measured in Sieverts (Sv).
Radioactivity	The spontaneous decay of an unstable atomic nucleus giving rise to the emission of radiation.
Reasonably Assured Resources (RAR)	Category from the NEA / IAEA uranium resource classification scheme which refers to uranium that occurs in known mineral deposits of delineated size, grade and configuration such that the quantities which could be recovered within the given production cost ranges with currently proven mining and processing technology, can be specified.

Reprocessing	The chemical separation of uranium and plutonium from used fuel. It allows the recycling of valuable fuel material and minimises the volume of high level waste material.
Separative Work Unit (SWU)	The capacity of an enrichment plants is measured in terms of 'separative work units' or SWU. The SWU is a function of the amount of uranium processed and the degree to which it is enriched (i.e. the extent of increase in the concentration of the U-235 isotope relative to the remainder) and the level of depletion of the remainder. About 100-120 000 SWU is required to enrich the annual fuel loading for a typical 1 000 MWe light water reactor.
Sievert (Sv)	Unit indicating the biological damage caused by radiation. One Joule of beta or gamma radiation absorbed per kilogram of tissue has 1 Sv of biological effect; 1 J/kg of alpha radiation has 20 Sv effect and 1 J/kg of neutrons has 10 Sv effect.
Tails (or enrichment tails)	The relatively depleted fissile uranium (U-235) which is the waste stream from the uranium enrichment process.
Tailings	The remaining portion of a metal-bearing ore consisting of finely ground rock and process liquids after some or all of the metal, such as uranium, has been extracted.
Tailings dam	Facility where tailings / mill residues are stored after treatment.
Transuranics	Very heavy elements formed artificially by neutron capture and possibly subsequent beta decay(s). Has a higher atomic number than uranium (92). All are radioactive. Neptunium, plutonium, americium and curium are the best-known.
Uranium deposit	A mass of naturally occurring mineral from which uranium could be exploited at present or in the future.
Uranium oxide concentrate (UOC)	The mixture of uranium oxides produced after milling uranium ore from a mine. UOC is khaki in colour and is usually represented by the empirical formula U_3O_8. Uranium is sold in this form (or as hydrated uranium peroxide, $UO_4.2H_2O$, which is the product of in-situ

	leach uranium mining). The concentrate usually contains some impurities such as sulphur, silicon and zircon. The quantity of U_3O_8 equivalent is determined by assay after drumming of the concentrate. UOC is sometimes loosely, but mistakenly, referred to as 'yellowcake'.
U-233 (or U^{233})	Isotope 233 of uranium, produced through neutron irradiation of thorium-232.
U-235 (or U^{235})	Isotope 235 of uranium (occurs as 0.711% of natural uranium, comprising 92 protons and 143 neutrons.
U-238 (or U^{238})	Isotope 238 of uranium (occurs as about 99.3% of natural uranium), comprising 92 protons and 146 neutrons.
UF_6	Uranium hexafluoride, a gaseous compound of uranium and fluorine used as feedstock for most enrichment processes.
UO_2	Uranium dioxide, a chemical form of uranium commonly used in power reactors.
U_3O_8	Triuranium octaoxide (commonly referred to as uranium oxide), produced as a result of uranium mining and milling.
Watt (W)	International System of Units standard unit of power, which is the rate of conversion (or transfer) of energy per unit time. One watt is the equivalent of one joule per second. One kilowatt (kW) is equal to one thousand watts, one megawatt (MW) is equal to one million watts, one gigawatt (GW) is equal to one billion watts, and one terawatt (TW) is equal to one trillion watts.
Weapons of mass destruction (WMD)	Refers to nuclear, chemical, biological and occasionally radiological weapons.
Yellowcake	A name originally given to the bright yellow substance ammonium diuranate, which is the penultimate uranium compound in U_3O_8 production.

List of recommendations

3 Australia's uranium resources, production and exploration

Recommendation 1

The Committee recommends that the Australian Government introduce a flow-through share scheme for companies conducting eligible minerals and petroleum exploration activities in Australia.

Recommendation 2

The Committee recommends that Geoscience Australia be granted additional funding to develop and deploy new techniques, including airborne electromagnetics, to provide precompetitive geoscience of prospective areas, in order to assist in the discovery of new world-class uranium and other mineral deposits located under cover and at depth.

6 The safety of the nuclear fuel cycle

Recommendation 3

To provide greater assurance to workers and the public at large, and also to definitively answer claims—which the Committee is confident are entirely mistaken—that current radiation exposures are harming workers, the Committee recommends that the Australian Government, in conjunction with state governments and industry, establish:

- a national radiation dose register for occupationally exposed workers; and
- a system of long-term monitoring of the health outcomes for workers occupationally exposed to radiation in uranium mining, associated industries and nuclear facilities.

The Committee further recommends that the Australian Government:

- jointly fund the health monitoring program with industry; and
- periodically publish the monitoring data, indicating any link between radiation exposures and health outcomes for these workers.

7 The global non-proliferation regime

Recommendation 4

The Committee recommends that the Minister for Foreign Affairs:

- seek, through all relevant fora, to impress on other countries the central importance of the non-proliferation aspects of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) and the security benefits of the NPT for all countries;
- redouble efforts to encourage adoption by other countries of an Additional Protocol to their safeguards agreements with the International Atomic Energy Agency (IAEA);
- advocate strengthening the verification regime so that the IAEA is empowered to more thoroughly investigate possible parallel weaponisation activities;
- seek the development of criteria for assessing the international acceptability of proposed sensitive projects, particularly in regions of tension, and advocate the development of a more rigorous verification regime for countries that either possess or choose to develop sensitive facilities;
- support proposals for nuclear fuel supply guarantees for those countries who waive the right to develop enrichment and reprocessing technologies; and
- come to a considered view about the adequacy of the resources currently allocated to the IAEA's safeguards program and, if deemed necessary, advocate within the IAEA Board of Governors for an increased allocation of resources to verification activities and recommend increased contributions from member states.

10 Uranium industry regulation and impacts on Aboriginal communities

Recommendation 5

The Committee recommends that the Australian Government provide adequate funding to ensure the rehabilitation of former uranium mine sites, and for towns and similar facilities, rehabilitation to meet the expectations of the local community.

Recommendation 6

The Committee recommends that the Australian Government examine expanding the role performed by the Office of Supervising Scientist (OSS) in relation to the monitoring and approvals for uranium mines. As an example, the OSS could be given a formal role in advising the Minister for the Environment and Heritage in relation to all uranium mine assessments and approvals under the *Environment Protection and Biodiversity Conservation Act* and the Minister for Industry, Tourism and Resources in relation to the conditions for granting uranium export licenses.

Given the proposed expanded role for the OSS, the Committee further recommends that the Environmental Research Institute of the Supervising Scientist (ERISS) be provided with additional resources, potentially in partnership with a suitable university, so as to provide a national research function. The OSS should continue to be able to refer matters to ERISS for research, but ERISS's autonomy should be preserved in terms of the conduct of research and the release of its findings.

Recommendation 7

The Committee recommends that the Australian Government work with industry, Indigenous groups and state/territory governments to develop strategies to improve Indigenous training and employment outcomes at uranium mines, with consideration given to studying and, if possible, emulating the strategies employed by Cameco Corporation and governments in Canada. The Committee further recommends that, where appropriate, mining companies consider employing Aboriginal liaison officers with direct access to management.

To ensure adequate local community consultation, the Committee further recommends that a process be established whereby it and its successor committees be formally given access to new uranium mine sites, with customary powers of inquiry and report to the Parliament. This process should formally provide for affected local governments to nominate a person to liaise with the Committee about any community concerns.

11 Impediments to the uranium industry's development

Recommendation 8

The Committee recommends that the Australian Government Minister for Industry, Tourism and Resources, through the Council of Australian Governments and other means, encourage state governments to reconsider their opposition to uranium mining and abolish legislative restrictions on uranium (and thorium) mining and exploration, where these exist.

Recommendation 9

The Committee recommends that the Australian Government, through the Council of Australian Governments, seek to remedy the impediments to the development of the uranium industry identified in this report and, specifically:

- develop uniform and minimum effective regulation for uranium exploration and mining across all states and territories;
- ensure that processes associated with issues including land access, Native Title, assessment and approvals, and reporting are streamlined;
- where possible, minimise duplication of regulation across levels of government;
- address labour shortages, training and skills deficits relevant to the industry; and
- address transportation impediments, and particularly issues associated with denial of shipping services.

Recommendation 10

The Committee recommends that the Australian Government, through the Council of Australian Governments, examine incident reporting requirements imposed on uranium mining companies with a view to aiding public understanding of the real impacts of incidents that may occur at uranium mines. Specifically, the Committee recommends that companies continue to meet existing reporting thresholds, but that regulators be required to issue a brief assessment of each incident informing the public of the gravity of the incident and its likely impacts on the environment and human health. To this end, a simple and accurate incident impact classification system could be devised.

Recommendation 11

The Committee recommends that the Australian Government:

- identify and fund an authoritative scientific organisation to prepare and publish objective information relating to uranium mining, the nuclear fuel cycle and nuclear power, including radiation hazards and radioactive waste management;
- support the scientific organisation identified above to develop a communication strategy to provide information to the public, media and political leaders to address concerns these groups may have in relation to uranium mining, uranium exports and nuclear power;
- seek to rectify any inaccuracies or lack of balance in school and university curricula pertaining to uranium mining and nuclear power;
- encourage industry bodies, including state chambers of mines, to conduct or augment programs to educate teachers, media and political leaders about the uranium industry;
- encourage companies to conduct programs of visits to uranium mines for teachers, school groups, media representatives and political leaders; and
- encourage industry to be forthright in engaging in public debate, where this may assist in providing a more balanced perspective on the industry and its impacts.

12 Value adding — fuel cycle services industries, nuclear power, skills and training in Australia

Recommendation 12

The Committee recommends that the Australian and state governments, through the Council of Australian Governments:

- examine how Australia might seek greater beneficiation of its uranium resources prior to export and encourage such a development, while meeting non-proliferation objectives proposed in initiatives such as the US Global Nuclear Energy Partnership (GNEP) and the International Atomic Energy Agency's (IAEA) proposed multilateral approaches to the nuclear fuel cycle;
- examine the possible establishment of fuel cycle facilities (for example, uranium conversion and enrichment plants) which, in

accordance with the IAEA's recommendation for such facilities to be operated on a multilateral basis, could be operated on a joint ownership, co-management or drawing rights basis with countries in the region intending to use nuclear energy in the future;

- examine whether, in light of the advances in spent fuel management proposed in the GNEP initiative, there is in fact a potential role for Australia in the back-end of the fuel cycle;
- in the event these proposals are adopted, develop a licensing and regulatory framework, that meets world's best practice, to provide for the possible establishment of fuel cycle services industries and facilities in Australia; and
- having established an appropriate regulatory regime, remove legislative impediments to the establishment of nuclear fuel cycle facilities in Australia and, specifically, repeal or amend:
  - ⇒ Section 140A of the *Environment Protection and Biodiversity Conservation Act 1999*, and
  - ⇒ Section 10 of the *Australian Radiation Protection and Nuclear Safety Act 1998.*

The Committee further recommends that such examination take account of full life cycle costs and benefits of the proposed facilities.

Recommendation 13

The Committee recommends that the Australian Government take steps to rebuild Australia's nuclear skills base and expertise by:

- broadening the Australian Nuclear Science and Technology Organisation's (ANSTO) research and development mandate, so that it is able to undertake physical laboratory studies of aspects of the nuclear fuel cycle and nuclear energy that may be of future benefit to Australia and Australian industry;
- developing a program whereby Australian nuclear scientists and engineers are assisted to study at overseas universities and/or to be placed with companies where relevant expertise resides, in order to expand Australia's knowledge base;
- increasing engagement by Australian nuclear scientists and engineers at a technical level with the International Atomic Energy Agency, for example through a program of secondments and placements;

- examining the possibility of re-establishing at least one Australian University School of Nuclear Engineering and an Australian Research Council Research Network or Centre(s) of Excellence in the relevant fields;
- encouraging industry to increase its collaborations with and support of ANSTO's proposed expanded research activities and any school of nuclear engineering that may be established; and
- encouraging greater university research into aspects of nuclear energy and the nuclear fuel cycle through the allocation of research grants awarded by the Australian Institute of Nuclear Science and Engineering.

Recommendation 14

The Committee recommends that the Australian Government:

- negotiate an appropriate subscription for Australia to the International Thermonuclear Experimental Reactor project on a whole-of-Government basis;
- support the establishment of a national research centre to consolidate and coordinate Australia's efforts in fusion related research; and
- examine the merits of establishing fusion science as a national research priority.

Executive summary

Introduction

The terms of reference for the case study were to inquire into and report on the strategic importance of Australia's uranium resources. The Committee was asked to give particular attention to the: global demand for Australia's uranium resources and associated supply issues; potential implications for global greenhouse emission reductions from the further development and export of Australia's uranium resources; and the current regulatory environment of the uranium mining sector.

The Committee indicated in its letters inviting submissions that it would also welcome comments in relation to six additional issues, relating to: whole of life cycle waste management; adequacy of social impact assessment, consultation and approval processes with traditional owners; health risks to workers and to the public from exposure to radiation; adequacy of regulation of uranium mining by the Commonwealth; the extent of federal subsidies and other mechanisms to facilitate uranium mining; and the effectiveness of safeguards regimes in addressing proliferation.

These matters are addressed in the Committee's report, which consists of 12 chapters. The contents, findings and recommendations of each chapter are summarised as follows.

The Committee's conclusions and recommendations are also summarised in a *key messages* section at the beginning of each chapter and in the *conclusions* section at the end of each chapter.

Chapter one: Introduction

The chapter outlines the referral of the inquiry to the Committee, the conduct of the inquiry, and the structure of the report and its principal findings.

Chapter two: Uranium: Demand and Supply

The Committee commences the report by considering the global demand and supply of uranium in the context of world electricity consumption trends and nuclear power's share in the electricity generation mix. The Committee provides a summary of forecasts for world nuclear generating capacity and associated uranium requirements. Competing views on the outlook for new nuclear power plant construction are then considered, followed by an assessment of the role of existing plant performance in influencing the demand for uranium.

The chapter commences with an overview of the nuclear fuel cycle, which establishes a context for the discussion in subsequent chapters of matters including greenhouse gas emissions, waste, safety and proliferation risks associated with nuclear power generation.

Demand for uranium is a function of nuclear generating capacity in operation worldwide, combined with the operational characteristics of reactors and fuel management policies of utilities.

There are currently 441 commercial nuclear power reactors operating in 31 countries. In 2005, nuclear reactors generated 2 626 billion kilowatt-hours of electricity, representing approximately 16 per cent of world electricity production. Some 27 nuclear reactors are currently under construction and a further 38 are planned or on order worldwide.

Expectations of increased world nuclear generating capacity and demand for uranium are underpinned by:

- forecasts for growth in world electricity demand, particularly in China and India;
- improved performance of existing nuclear power plants and operating life extensions;
- plans for significant new nuclear build in several countries and renewed interest in nuclear energy among some industrialised nations; and
- the desire for security of fuel supplies and heightened concerns about greenhouse gas emissions from the electricity sector.

New reactor construction combined with capacity upgrades and life extensions of existing reactors are projected to outweigh reactor shutdowns over the next two decades, so that world nuclear capacity will continue to increase and thereby increase projected uranium requirements.

Several forecasts for world nuclear generating capacity and uranium requirements have been published. A conservative forecast by the International Atomic Energy

Agency (IAEA) and OECD Nuclear Energy Agency (OECD-NEA) predicts that nuclear generating capacity will grow to 448 gigawatts electrical by 2025, representing a 22 per cent increase on current capacity. This would see annual uranium requirements rise to 82 275 tonnes by 2025, also representing a 22 per cent increase on the 2004 requirements of 67 430 tonnes.

Uranium mine production currently meets only 65 per cent of world reactor requirements. The balance of requirements are met by secondary sources of supply, notably inventories held by utilities and ex-military material. Secondary supplies are expected to decline over coming years and the anticipated tightness in supply has been reflected in a seven-fold increase in the uranium spot market price since December 2000.

The Committee concludes that new nuclear build combined with improved reactor performance and operating life extensions are likely to outweigh reactor retirements in the years ahead, thereby increasing projected uranium requirements. Importantly, secondary supplies are also declining, leading to an increased requirement for uranium mine production. The dramatic increases in the uranium spot price are stimulating new uranium exploration activity.

The Committee notes that Australia possesses some 36 per cent of the world's Reasonably Assured Resources of uranium recoverable at low cost. However, Australia only accounts for 23 per cent of world production and lags behind Canada (which has less than half Australia's resources in this category). The Committee concludes that provided the impediments to the industry's growth are eliminated, there is great potential for Australia to expand production and become the world's premier supplier of uranium.

Notwithstanding the current tightness in the uranium market, the Committee notes that sufficient uranium resources exist and are likely to be discovered to support significant growth in nuclear capacity in the longer-term.

Chapter three: Australia's uranium resources, production and exploration

The chapter provides a detailed overview of Australia's uranium resources, mine production and exploration for uranium.

The Committee notes that Australia possesses 38 per cent of the world's total Identified Resources of uranium, recoverable at low cost (less than US$40 per kilogram). According to company reports, Australia's known uranium deposits currently contain a total of over 2 million tonnes of uranium oxide in in-ground resources. The in-situ value of this resource at spot market prices prevailing in June 2006 was over A$270 billion.

Some 75 per cent of Australia's total Identified Resources of uranium are located in South Australia, but significant deposits are also located in the Northern Territory, Western Australia and Queensland.

Seven of the world's 20 largest uranium deposits are in Australia—Olympic Dam (SA), Jabiluka (NT), Ranger (NT), Yeelirrie (WA), Valhalla (Queensland), Kintyre (WA) and Beverley (SA).

In addition to its uranium resources, Australia also possesses the world's largest quantity of economically recoverable thorium resources—300 000 tonnes—more than Canada and the US combined. Like uranium, thorium can be used as a nuclear fuel, although the thorium fuel cycle is not yet commercialised.

In 2005, Australia achieved record national production of 11 222 tonnes of uranium oxide from three operational mines—Ranger, Olympic Dam and Beverley. Beverley is the world's largest uranium mine employing the in-situ leach (ISL) mining method and a fourth uranium mine (also employing the ISL method), Honeymoon, is anticipated to commence production during 2008.

A proposal to expand Olympic Dam would see uranium production from the mine treble to 15 000 tonnes of uranium oxide per year, which would make Olympic Dam and its owners, BHP Billiton, by far the world's largest producer. The expanded mine would account for more than 20 per cent of world uranium mine production and Australia would become the world's largest supplier of uranium with a doubling of national production.

Australia exported a record 12 360 tonnes of uranium oxide in 2005. This quantity of uranium was sufficient for the annual fuel requirements of more than 50 reactors (each of 1 000 megawatt electrical capacity), producing some 380 terawatt-hours of electricity in total—some one and a half times Australia's total electricity production. The value of uranium exports reached a record high of $573 million in 2005. The outlook for further increases in production and export earnings is positive.

The increase in uranium price and the anticipated decline in secondary supplies have stimulated a resurgence in exploration activity and expenditure in Australia. In 2005, total exploration expenditure for uranium was $41.09 million, which was almost a three-fold increase on 2004 expenditure.

While there has been a trend of increasing exploration expenditure since early 2003, there has been relatively little exploration for uranium over the past two decades and Australia's known uranium resources generally reflect exploration efforts that took place 30 years ago. The size of Australia's known uranium resources significantly understates the potential resource base and there is great potential for new and significant discoveries.

In its previous report, which addressed impediments to exploration, the Committee accepted that future world-class uranium deposits are likely to be located at greater depths than those hitherto discovered. It was concluded that this will require large injections of exploration investment capital to overcome the technical challenges of locating bedrock deposits. These observations reinforce the need to ensure that juniors, which are generally efficient explorers, are appropriately assisted to discover Australia's future world-class uranium and other mineral deposits. The Committee is convinced of the merits of flow-through share schemes and repeats the recommendation contained in its previous report **[Recommendation 1]**.

To assist in the discovery of new world-class uranium deposits the Committee recommends that Geoscience Australia be provided with additional funding to develop and deploy techniques to provide precompetitive geoscience of prospective areas, in order to assist in the discovery of new world-class uranium and other mineral deposits located under cover and at depth **[Recommendation 2]**.

Chapter four: Greenhouse gas emissions and nuclear power

The chapter addresses the greenhouse gas emissions avoided by the use of nuclear power, emissions across the whole nuclear fuel cycle, the contribution from renewable energy sources, and the relative economic attractiveness of nuclear power for baseload power generation.

The Committee notes that electricity generation is the largest and fastest growing contributor to global carbon dioxide (CO_2) emissions, responsible for 40 per cent of global emissions in 2003—10 billion tonnes of CO_2. Emissions from electricity are projected to contribute approximately 50 per cent of the increase in global CO_2 emissions to 2030.

The Committee concludes that nuclear power unquestionably makes a significant contribution to the mitigation of greenhouse gas (GHG) emissions—nuclear power plants currently save some 10 per cent of total CO_2 emissions from world energy use. This represents an immense saving of GHG emissions that would otherwise be contributing to global warming. If the world were not using nuclear power plants, emissions of CO_2 would be some 2.5 billion tonnes higher per year.

Australia's uranium exports displace some 395 million tonnes of CO_2 each year, relative to black coal generation, and this represents some 70 per cent of Australia's total GHG emissions for 2003. Evidence suggested that the cumulative carbon savings from nuclear power over the three decades to 2030 will exceed 25 billion tonnes.

In addition to its GHG mitigation benefits, nuclear power also offsets the vast emissions of sulphur dioxide, nitrous oxide and particulates which are produced by fossil fuelled plants.

The Committee notes the support shown for nuclear power by several foundational figures of the environment movement. These individuals now perceive that the risks associated with the expanded use of nuclear power are insignificant in comparison to the threat posed by the enhanced greenhouse effect and global warming. The Committee also notes calls by some in industry that, in view of the energy demands from heavily populated developing nations, Australia in fact has a moral responsibility to contribute to reducing global GHG emissions through the increased production and supply of uranium.

It was claimed that nuclear power will not solve climate change because it only reduces emissions from the electricity sector, which is only one source of anthropogenic GHG emissions. The Committee notes, however, that no representative of the uranium industry ever claimed that nuclear power alone could 'solve' climate change. In fact, it was repeatedly stated that nuclear power is one—albeit significant—part of the solution to global warming.

Although nuclear power has the potential to reduce emissions in the transport sector through the production of hydrogen, nuclear's greenhouse mitigation contribution is currently limited to the electricity sector. However, electricity generation, which is already the largest contributor of CO_2 emissions at 40 per cent of the global total, is also the fastest growing. It is imperative that emissions from this sector be reduced.

The Committee finds that over its whole fuel cycle nuclear power emits very small quantities of CO_2 (2–6 grams of carbon per kilowatt-hour of electricity produced). This is two orders of magnitude less than coal, oil and natural gas, and is comparable to emissions from wind and solar power.

Evidence suggested that renewables and energy efficiency measures *alone* have no prospect of meeting rapidly growing demands for energy and abating greenhouse emissions to the degree required. The weight of evidence points to the need for a mix of low-emission energy sources and technologies, in which nuclear power will continue to play a significant part.

In the context of rapidly growing energy demand, particularly from developing nations, nuclear power represents the only means of limiting increased emissions while meeting the world's voracious appetite for energy. While the Committee recognises that there is a role for renewables, and certainly for greater use of efficiency measures, renewables are limited in their application by being intermittent, diffuse and pose significant energy storage problems. Renewables also require substantial backup generation, which needs to be provided by conventional baseload power sources. Promised baseload contributions from geothermal, which will be welcome, are yet to be developed on any scale.

The Committee believes that the 'nuclear versus renewables' dichotomy, which was explicit in some submissions, is a false debate and misses the point: while renewables have a contribution to make, other than hydro and (potentially) geothermal, they are simply not capable of providing baseload power on a large scale. The relevant comparison, if one needs to be made, is between baseload alternatives. On this issue the evidence is clear—nuclear power is the only proven technology for baseload power supply which does not release substantial amounts of CO_2.

The Committee also recognises that given its comparative advantage in fossil fuels and the world's projected continued reliance on fossil fuels, Australia has a strong economic interest in supporting technologies that reduce the greenhouse intensity of these fuels. The Committee agrees that nuclear power should not be seen as competing with or substituting for clean coal technologies, and indeed renewables such as photovoltaics in which Australia has expertise.

A vital consideration in assessing nuclear power's viability as a GHG emission mitigation option relates to the economic competitiveness of nuclear power relative to other baseload alternatives. Evidence suggests that nuclear power plants have higher capital/construction costs than either coal or gas plants, which are characterised by mid-range and low capital costs respectively. However, nuclear plants have low fuel, operating and maintenance costs relative to the fossil fuel alternatives.

A range of recent studies have concluded that, in many industrialised countries, nuclear power is competitive with gas and coal-fired electricity generation, even without incorporating an additional cost for the carbon emissions from the fossil fuelled plants. Factors that influence the suitability of deploying nuclear plants in a particular situation include the projected prices of natural gas and coal, the discount rate employed, proximity and access to fuel sources such as low cost fossil fuels, and the quality of fuel sources.

Although nuclear plants generally have higher capital costs, the Committee notes there are developments which promise to reduce the construction costs and construction times for new plants, including possible regulatory reforms in the US and new plant designs. It seems clear that replicating several reactors of one design, or standardising reactors, reduces levelised generating costs considerably.

Although again the Committee does not wish to enter into a nuclear versus renewables debate, evidence suggests that renewables, particularly wind, have consistently higher generating costs than nuclear plants. These costs are even higher if the necessity for standby generation is included.

The Committee concludes that, in addition to security of energy supply and near-zero GHG emissions, nuclear power offers at least three economic advantages relative to other baseload energy sources: price stability, very low operating costs and internalisation of costs that are not incorporated in the cost of other sources of electricity, notably waste management.

Chapter five: Radioactive waste

The chapter addresses the management of radioactive waste generated across the nuclear fuel cycle, from uranium mining to the decommissioning of nuclear power plants. This is the first of three issues which critics of uranium mining and nuclear power claim are fatal for the civil nuclear power industry. The other two issues relate to safety and proliferation, which are addressed in the following three chapters.

While some radioactive waste is produced at each stage of the nuclear fuel cycle, the volumes of high level waste (HLW) are extremely small, contained and have hitherto been safely managed.

The Committee finds that HLW has several features which lends itself to ease of management: very small volumes; the radioactivity is contained in the spent fuel assemblies; it decays at a predictable rate; and is amenable to separation, encapsulation and isolation. Moreover, the nuclear power industry significantly contributes to the cost of its waste management through levies imposed on utilities. That is, the cost of managing radioactive waste is internalised in the price of the electricity generated.

In short, nuclear power deals with its waste more explicitly and transparently than many other sources of energy.

The generation of electricity from a typical 1 000 megawatt (MWe) nuclear power station, which would supply the needs of a city the size of Amsterdam, produces approximately 25–30 tonnes of spent fuel each year. This equates to only three cubic metres of vitrified waste if the spent fuel is reprocessed. By way of comparison, a 1 000 MWe coal-fired power station produces some 300 000 tonnes of ash alone per year.

HLW is accumulating at 12 000 tonnes per year worldwide. The International Atomic Energy Agency (IAEA) states that this volume of spent fuel, produced by all of the world's nuclear reactors in a year, would fit into a structure the size of a soccer field and 1.5 metres high—even without any being reprocessed for re-use. This contrasts with the 25 billion tonnes of carbon waste released directly into the atmosphere each year from the use of fossil fuels.

To date, there has been no practical need and no urgency for the construction of HLW repositories. This has been due to the small volumes of waste involved and the benefit of allowing interim storage for up to several decades to allow radioactivity to diminish so as to make handling the spent fuel easier.

There is an international scientific consensus that disposal in geologic repositories can safely and securely store HLW for the periods of time required for the long-lived waste to decay to background levels.

While plans for geologic repositories are now well advanced in several countries, finding sites for repositories has been problematic. This has been due in large part to a lack of public acceptance. 'Not in my backyard' arguments about the siting of repositories have been fuelled by misperceptions of the level of risk involved in radioactive waste management and the operation of repositories. However, some countries, notably Finland and Sweden, have managed this process successfully and with a high degree of public involvement and support.

Transport of radioactive waste is undertaken safely and securely—in sharp contrast to other energy industries. Since 1971, there have been more than 20 000 shipments of spent fuel and HLW over more than 30 million kilometres. There has never been any accident in which a container with highly radioactive material has been breached or leaked. In contrast, in OECD countries over the past 30 years more than 2 000 people have been killed in accidents involving the transport of LPG.

Advanced nuclear reactors and spent fuel reprocessing technologies are now being developed which will significantly reduce the quantity and toxicity of nuclear waste, potentially reducing the required isolation period to just a few hundred years and further reducing the disposal/storage space required. These technological advances could potentially obviate the need for geologic repositories altogether.

Nuclear power utilities are charged levies to provide funds for the management of the industry's waste and for the eventual decommissioning of plants. In the US, the Nuclear Waste Fund now amounts to over US$28 billion, while more than US$23 billion has been set aside for decommissioning. These costs are factored into the cost of the electricity generated and the prices paid by consumers.

In contrast, wastes from fossil fuel power are not contained or managed, involve enormous volumes and a range of toxic pollutants that do not decay. Moreover, the cost of the environmental externalities these energy sources create are generally not factored into the price of the electricity produced.

The Committee concludes that claims that the generation of radioactive waste, its management and transportation pose unacceptable risks simply do not reflect the realities. Some submitters misperceive the risks involved and either misunderstand or ignore the historical record. The facts indicate that the radioactive wastes generated at the various stages of the nuclear fuel cycle continue to be safely and effectively managed. Indeed, the way in which the nuclear power industry manages its waste is an example for other energy industries to follow.

Chapter six: The safety of the nuclear fuel cycle

The chapter examines the second key concern raised in opposition to the civil nuclear power industry—the safety of nuclear fuel cycle facilities, and particularly the health risks to workers and to the public from exposure to radiation from uranium mining and nuclear power plants.

The Committee concludes that nuclear power, like all other major energy industries, is not and nor could it ever be entirely risk free. However, notwithstanding the Chernobyl accident, which has been the only accident to a commercial nuclear power plant that has resulted in loss of life in over 50 years of civil nuclear power generation (over 12 000 cumulative reactor years of commercial operation in 32 countries), nuclear power's safety record surpasses that of all other major energy industries.

While the Chernobyl accident could lead, over the lifetime of the most exposed populations, to several thousand excess cancer deaths, other energy sources are responsible for killing thousands of workers and members of the public every year. For example, in addition to catastrophic events (e.g. 3 000 immediate fatalities in an oil transport accident in 1987 and 2 500 immediate fatalities in a hydro accident in 1979), more than 6 000 coal miners die each year in China alone. Evidence suggests that coal mining worldwide causes the deaths of 12 000 to 15 000 miners each year. Even in Australia, 112 coal miners have died in NSW mines alone since 1979.

Moreover, the numbers of fatalities cited do not include the deaths and other health impacts likely to be caused by the release of toxic gases and particulates from burning fossil fuels. Neither do these considerations consider the possible health impacts and other risks associated with climate change arising from fossil fuel use.

In any case, the Committee notes that the multi UN agency Chernobyl Forum report found that the most pressing health problem for areas most affected by the Chernobyl accident is *not* radiation exposure but poor life style factors associated with alcohol and tobacco use, as well as poverty. The largest public health problem has been the mental health impact of the accident. The Forum concluded that persistent 'misconceptions and myths' about the threat of radiation have promoted a 'paralysing fatalism' among residents.

The Chernobyl accident resulted from a flawed Soviet reactor design which would never have been certified for operation under regulatory regimes of western nations. The reactor was operated with inadequately trained personnel and without proper regard for safety. In addition, the Chernobyl plant did not have a containment structure common to most nuclear plants elsewhere in the world.

In terms of the health hazards from the routine operations of nuclear fuel cycle facilities, evidence suggests that occupational radiation exposures are low. In fact, the average annual effective radiation dose to monitored nuclear industry workers is less than the exposure of air crew in civil aviation, and is also less than the radon exposure in some above-ground workplaces.

Globally, exposure by the general public to radiation from the whole fuel cycle is negligible. The average annual natural background radiation exposure is 2.4 millisieverts (mSv). In comparison, the average dose received by the public from nuclear power production is 0.0002 mSv and, hence, corresponds to less than one ten thousandth the total yearly dose received from natural background.

Radiation exposure for workers at Australian uranium mines is well below (less than half) the prescribed average annual limit for workers of 20 mSv. The radiation exposure for the public in the vicinity of the mines is also far below the prescribed level of 1 mSv for members of the public. Indeed, at Beverley in South Australia, the nearest members of the public received a dose less than one hundredth the prescribed limit in 2005.

The Committee acknowledges there have been incidents at the Ranger mine in the Northern Territory, for which the mining company has been prosecuted. This is evidence of a willingness by regulators to pursue the company where necessary, contrary to the claims by the industry's opponents. The Committee notes that the company itself acknowledges that its performance in 2004 was not adequate and has taken steps to improve. The Australian Government is satisfied that the company has met the conditions required of it.

The Committee is persuaded that uranium industry workers in Australia are not being exposed to unsafe doses of radiation. However, to provide greater assurance to workers and the public at large, and also to definitively answer claims—which the Committee is confident are entirely mistaken—that current radiation exposures are harming workers, the Committee recommends the establishment of:

- a national radiation dose register for selected occupationally exposed workers; and
- a system of long-term monitoring of the health outcomes for workers occupationally exposed to radiation in uranium mining, associated industries and nuclear facilities **[Recommendation 3]**.

In the Committee's view, some critics of uranium mining and nuclear power misconceive or exaggerate the health risks from the industry's operations, for example, by wildly inaccurate assessments of the deaths attributable to the routine operations of the industry and dismissing the Chernobyl Forum as a 'whitewash'. Such views have however influenced wider public opinion and public policy in a way detrimental to the industry, and have reduced the potential community and global benefits from use of nuclear power.

The Committee concludes that there is a clear need for improved public understanding of the nature of radiation and the effects of the actual exposures to the public from the nuclear industry's operations.

Chapter seven: The global non-proliferation regime

In this and the following chapter the Committee addresses the third objection to the use of nuclear power—nuclear proliferation and the effectiveness of safeguards regimes.

Chapter seven first introduces the concept of proliferation and explains how some technologies required in the civil nuclear fuel cycle also have military uses. The Committee describes the current global non-proliferation regime, the key elements of which are the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) and the safeguards activities of the IAEA.

While submitters acknowledged that improvements have been made to IAEA safeguards in recent years, it was argued that a number of deficiencies remain. These alleged deficiencies and a response to each claim from the Australian Safeguards and Non-Proliferation Office (ASNO) are summarised in turn. Finally, the chapter presents an overview of measures recently proposed to address perceived vulnerabilities in the non-proliferation regime.

The Committee concludes that the global safeguards regime has indeed been remarkably successful in limiting the proliferation of nuclear weapons. Today, in addition to the five nuclear-armed states that existed prior to the NPT's entry into force in 1970, there are only four states that have or are believed to have nuclear weapons: the three non-NPT parties—Israel, India and Pakistan—and North Korea. This is clearly a tremendous achievement, particularly in light of predictions that by the end of the 20th century there would be some 25 to 30 nuclear armed states.

In response to the discovery of a clandestine weapons program in Iraq, which had a comprehensive safeguards agreement in force with the IAEA at the time, a range of safeguards strengthening measures have now been introduced. These measures enable the IAEA to draw conclusions about the absence of *undeclared* nuclear materials and activities in countries, in addition to the assurance provided under traditional safeguards about the non-diversion of *declared* nuclear material and activities. The Committee considers that these measures are clearly a great advance.

Central to the safeguards strengthening measures has been the adoption by states of an Additional Protocol (AP) to their safeguards agreements with the IAEA. APs require states to provide the IAEA with broader information, allow the IAEA wider access rights and enable it to use the most advanced verification technologies. The Committee is pleased to note the Australian Government's strong support for the AP, its prominent role in the AP's formulation and that Australia was the first country to sign and ratify an AP. The Committee also welcomes the Government's decision to make the AP a condition for the supply of uranium to non-nuclear weapons states (NNWS).

However, the Committee is concerned that the uptake of APs remains slow. As of July 2006, only 77 countries had APs in force. The Committee notes with concern the IAEA Director General's comment that the Agency's verification efforts will not be judged fully effective on a global scale as long as its access rights remain uneven. The AP must become the universal standard for verifying nuclear non-proliferation commitments. The Committee urges the Australian Government to redouble its efforts to encourage adoption of APs by other countries.

Submitters alleged that there are a range of deficiencies and limitations to the NPT/IAEA safeguards regime. While the Committee believes that most of these alleged deficiencies are without substance, it notes that the non-proliferation regime is now facing several challenges. The Committee concurs with the Minister for Foreign Affairs that these challenges must be met so that the public can be confident that an expansion of nuclear power (and of uranium exports) will not represent a risk to international security.

Among these challenges is the weakening of political support for the non-proliferation regime and the problem now presented by Iran, which claims the right to develop the *full* nuclear fuel cycle, ostensibly on the grounds of security of nuclear fuel supply. This raises the possibility that, having made full use of the alleged 'right' to acquire proliferation-sensitive technologies under Article IV of the Treaty, states could then withdraw from the NPT and pursue weapons programs.

The Committee notes that the claim of a right to pursue proliferation-sensitive technologies may indeed be a serious misreading of the Treaty, which speaks of the right of all parties to use *nuclear energy* for peaceful purposes and that this was never intended to mean development of *any* nuclear technology. It is clear that when the NPT was first negotiated it was envisaged that the nuclear weapons states (NWS) would provide these fuel cycle services to the NNWS. Moreover, the Committee notes that the right to use of nuclear energy is subject to the other provisions of the Treaty, notably the corresponding duties to comply with NPT and safeguards commitments—factors that seem to have been ignored by Iran and its supporters.

Nonetheless, the Committee is pleased to note that this dilemma is receiving considerable attention and that there are a range of proposals now being considered that will increase control over proliferation-sensitive technologies and limit their spread.

The Committee recommends that the Australian Government take steps to strengthen the non-proliferation regime, including seeking through all relevant fora to impress on other countries the central importance of the non-proliferation aspects of the NPT; redoubling efforts to encourage adoption by other countries of an AP to their safeguards agreements with the IAEA; supporting proposals for nuclear fuel supply guarantees for those countries that forego developing sensitive facilities; and reviewing the adequacy of the resources allocated to the IAEA's safeguards program **[Recommendation 4]**.

While the Committee acknowledges that technical measures to prevent proliferation are unlikely to be successful in the absence of political commitment, the Committee is encouraged to note that proliferation-resistant technologies are continuing to be developed. In particular, the Committee was informed about efforts to develop a nuclear fuel cycle that does not require enrichment and currently-established reprocessing technologies (which separate out plutonium that could potentially be diverted for weapons), and the development of reactor types that incorporate proliferation resistance into their designs.

Finally, the Committee welcomes the commendable range of efforts the Australian Government is undertaking to advance non-proliferation objectives. As a major uranium exporter and, potentially, as the world's largest uranium producer, Australia has a strong interest in ensuring that the material and technologies required for peaceful use of nuclear energy are not diverted for any military purpose.

Chapter eight: Australia's bilateral safeguards

The chapter considers the adequacy and effectiveness of Australia's safeguards policy and the bilateral safeguards agreements it enters into with countries wishing to purchase Australian uranium.

In addition to IAEA safeguards described in the previous chapter, Australia superimposes additional safeguards requirements through a network of bilateral safeguards agreements. The objectives of Australia's safeguards policy are to ensure that Australian Obligated Nuclear Material (AONM) is: appropriately accounted for as it moves through the fuel cycle; is used only for peaceful purposes; and in no way contributes to any military purpose.

Australia’s policy also establishes criteria for the selection of countries eligible to receive AONM. The Committee notes that of the five cases where the IAEA has found countries in non-compliance with their safeguards agreements and reported the non-compliance to the UN Security Council, none of these cases involved countries eligible to use Australian uranium.

While the Committee notes that it simply cannot be absolutely guaranteed that diversion of AONM for use in weapons could never occur at some point in the future, nevertheless the Committee is satisfied that Australia’s safeguards policy has been effective to date. The Committee concludes that the requirements in safeguards agreements are adequate and can see no reason for imposing additional requirements at this time.

The Committee rejects arguments that Australia’s safeguards policy has been eroded and stripped of its potency over time. In particular, the Committee believes that the principles of equivalence and proportionality, which underlie nuclear fuel trade, simply reflect that, other than by establishing the entire nuclear fuel cycle in Australia and leasing fuel elements, it is impossible to track ‘national atoms’ once uranium from different sources is mixed together (e.g. in enrichment and fuel fabrication processes). It is for this reason that international practice is to designate an equivalent quantity as (Australian) obligated nuclear material. In this way, even if at some point AONM is co-mingled with unsafeguarded material, a proportion of the resulting material will be regarded as AONM corresponding to the same proportion of AONM initially. Thus, even if a stream of material is taken from a process for military purposes (e.g. from a conversion facility), the presence of the AONM will in no way benefit or contribute to the quantity or quality of the unobligated material. In any case, the facilities where AONM can be processed, including in the NWS, must be safeguarded and are eligible for IAEA monitoring and inspections.

The Committee notes the strong objection by some submitters to the reprocessing of spent fuel containing Australian-obligated plutonium. While the Committee agrees that the existence of stocks of separated plutonium does represent a possible proliferation danger, it notes that reprocessing used fuel has a number of important advantages that must also be considered. Specifically, reprocessing and plutonium recycling enables a far more efficient use of the uranium fuel, extending by about one third the amount of energy a country can obtain from the uranium they purchase. Furthermore, reprocessing and use of mixed oxide fuel significantly reduces the amount of waste that must be disposed of.

The Committee concludes that there is little or no potential for the diversion of AONM for use by terrorists, or for AONM and other Australian radioactive materials to be used in 'dirty bombs'. In particular, the Committee notes that Australia's conditions for supply of AONM include an assurance that internationally agreed standards of physical security will be applied to nuclear materials in the country concerned.

The Committee was informed of the recent strengthening, under the IAEA's auspices, of several conventions and guidelines to protect against acts of nuclear terrorism, including significant amendments to the *Convention on the Physical Protection of Nuclear Materials* and the Code of Conduct for Safety and Security of Radioactive Sources.

The Committee is pleased to note that Australia has again been at the forefront in negotiating these outcomes, as well as contributing to nuclear security initiatives in the region, such as leading a project to ensure the security of radioactive sources.

The Committee supports the Australian Government's decision to permit exports of uranium to China.

The Committee belives that the US-India nuclear cooperation agreement will have a number of important non-proliferation benefits, including that it will expand the application of IAEA safeguards in India and allow the IAEA enhanced access rights. However, while there are sound reasons to allow an exception to Australia's exports policy in order to permit uranium sales to India, including its record as a non-proliferator, the Committee does not wish to make a recommendation on the matter. Maintaining the integrity of the non-proliferation regime must remain the top priority and guiding principle for Australia's uranium exports policy and the Committee hopes that a bipartisan position on this issue can be developed.

Chapter nine: Strategic importance of Australia's uranium resources

In addition to its greenhouse gas emission benefits, which were discussed in chapter four, evidence presented to the Committee suggested that the strategic importance of Australia's uranium resources also derives from the:

- significance of the resource as one of Australia's major energy exports;
- energy security benefits that uranium can provide those countries that choose to adopt nuclear power;
- potential for Australia's uranium exports to assist in addressing the global energy imbalance;
- economic benefits that may be obtained from uranium mining, particularly for state economies and regional communities;

- economic significance of Australia's undeveloped uranium resources; and
- Australia's role as a major uranium exporter in the global nuclear fuel cycle.

The chapter considers each of these points in turn.

The Committee finds that uranium is Australia's second largest energy export in thermal terms, which is of great importance given predictions for an increase in energy demand over the coming decades, particularly in developing countries. Uranium is an immensely concentrated source of energy—one tonne of uranium oxide generates the same amount of energy as 20 000 tonnes of black coal. The uranium produced from just one of Australia's mines each year—Ranger, in the Northern Territory—contains sufficient energy to provide for 80 per cent of Australia's total annual electricity requirements, or all of Taiwan's electricity needs for a year. Olympic Dam in South Australia contains uranium equivalent in energy content to 4.5 times the energy contained in the entire North-West Shelf gas field—25 billion tonnes of steaming coal.

The Committee concludes that nuclear power represents a significant means of addressing the global energy imbalance. It is an important component of the global energy mix, which can provide developing countries with access to the energy required to fuel their industrialisation and particularly their electricity requirements.

Uranium production currently generates considerable economic benefits and has the potential to make such contributions in states that currently prohibit uranium mining. In recognising the economic benefits of the industry, the Committee is conscious that failure to permit the development of the industry has corresponding costs. Such costs include loss of the industry's current and potential contribution to the national and state economies, regional development, services and employment in Aboriginal communities, and further promotion of Australia's role in the international nuclear community.

For example, it is estimated that the proposed expansion of Olympic Dam will increase South Australia's Gross State Product by about $1.4 billion and the number of jobs associated with the mine will increase by about 8 400.

The Committee notes that while precise estimates of the value of undeveloped uranium resources varies, one conservative estimate suggests that the locked up uranium in Australia could earn revenues in excess of A$32 billion (at prices prevailing in November 2005). Other estimates suggest that sales of uranium from WA alone could generate revenues of $1.6 billion per year.

The Committee notes that the further expansion of the nuclear power industry worldwide will not be dependent on Australian uranium and will proceed irrespective of whether or not Australia supplies uranium. If Australia fails to supply then marginally higher cost overseas resources will be supplied to meet global demand, and these resources may not be provided to the market with the same safeguards and other regulatory requirements imposed on Australian exports. However, Australia can contribute to international energy security by being a reliable and stable supplier of uranium.

In view of the strategic importance of Australia's uranium resources, the potential benefits from the further development of these resources, and following consideration of the alleged risks summarised in the previous four chapters, the Committee concludes that development of new uranium deposits should be permitted and encouraged.

Chapter ten: Uranium industry regulation and impacts on Aboriginal communities

The chapter examines the current structure and regulatory environment of the uranium mining sector (noting the work that has been undertaken by other inquiries and reviews on these issues), and consultation with Traditional Owners and the social impacts of uranium mining on Aboriginal communities.

While the regulation of uranium mining is principally a state and territory government responsibility, the Australian Government's interests and responsibilities in this area include:

- environmental assessment and approval of new uranium mines and significant expansion of existing mines;
- ownership of uranium in the NT; and
- oversight of uranium mining operations in the Alligator Rivers Region (ARR) of the NT through the Supervising Scientist Division of the Department of the Environment and Heritage.

Industry is generally supportive of state and territory governments regulating uranium mining, and is confident that the current regulatory regime is sufficiently stringent. Industry is concerned, however, with some of the complexity involved and perceived reporting regulations that exceed those of other minerals industries.

Criticisms of existing regulatory arrangements were largely directed to the adequacy of provisions for environmental protection from the impacts of uranium mining in the Kakadu National Park and the ARR. Criticisms were also made of the performance of the Office of Supervising Scientist (OSS), which, among a number of allegations, was said to have been 'captured' by Energy Resources of

Australia (ERA), owners of the Ranger mine. However, the OSS provided convincing rebuttals to each of these allegations, as well as to arguments relating to the adequacy of tailings and water management at Ranger.

The Committee rejects the claim that the regulation of uranium mining in the ARR is inadequate. There is extensive formal oversight of the Ranger operation and ERA meet some of the most rigorous reporting regimes in Australia. Ranger is monitored and regulated by a range of independent bodies including Australian Government agencies (OSS, ASNO and the Department of Industry, Tourism and Resources), NT Government agencies and independent review bodies, namely the Mine Site Technical Committees, ARR Advisory Committee and ARR Technical Committee.

Moreover, the Committee notes that monitoring and research by the OSS since 1978 has concluded that uranium mining operations at Ranger have had no detrimental impact on the Kakadu National Park. This confirms that the regulatory regime governing uranium mining in the ARR has indeed succeeded in protecting the environment from any harmful impacts caused by uranium mining.

Uranium mining regulation in the ARR has, however, evolved into what appears to be an unduly complex regime, comprised of arrangements underpinned by a range of Commonwealth and Territory legislation. The Committee recognises that the complexity may well have been unavoidable because of the combination of factors, including that: mining is taking place on Aboriginal land; the need to protect the Kakadu National Park; and the special nature of uranium. Nonetheless, if a regulatory framework were to be designed from 'scratch' in 2006, it seems unlikely that a similar framework would be developed. The Committee will not recommend specific improvements but suggests that the entire regulatory regime in the NT should be reviewed with a view to consolidation and simplification.

Although the Committee believes there have been clear improvements in environmental regulations relating to mine closure and rehabilitation, some partially rehabilitated former uranium mines continue to present pollution problems. The Australian Government's recent decision to allocate some additional funding to address this problem is welcome, but the Committee recommends that the Australian Government redouble efforts to completely rehabilitate former uranium mines and provide funding to do so **[Recommendation 5]**.

The Committee recommends that consideration should be given to utilising the expertise of the OSS in assessment and approvals processes for uranium mines generally. Mindful that industry wishes to see any unnecessary duplication across levels of government eliminated, the Committee urges that an expanded role for the OSS not add to what is already a highly regulated industry. The Committee further recommends that the Environmental Research Institute of the Supervising

Scientist be provided with additional resources, potentially in partnership with a suitable university, so as to provide a national research function **[Recommendation 6]**.

Despite professing concern that Indigenous groups be consulted, some environmental groups revealed that, should Traditional Owners approve a mining development, they would still oppose uranium mining. This seems to support the observation made by one submitter who remarked that Aboriginal groups are being used by some 'no development' groups to support their opposition to uranium mining. Traditional Owners' views are clearly *not* to be respected if they happen to support resource development.

Notwithstanding this, the Committee believes that care must be taken to ensure that uranium mining does not impact negatively on local Aboriginal communities. The Committee is of the view that the social impacts of mining operations must be adequately monitored, and Aboriginal communities and Traditional Owners should have an opportunity to share in the benefits associated with a vibrant minerals industry.

The Committee is not convinced that social problems are peculiar to uranium mining, or to Jabiru, Ranger and ERA, but rather that the social problems and issues of service provision in Jabiru are common to large Aboriginal communities wherever they are located.

In relation to employment, the Committee notes impediments to increasing Aboriginal engagement in the uranium industry, including the opposition by some Aboriginal groups and low levels of educational attainment. The Committee sees merit, however, in industry seeking to emulate the examples of mining operations that have succeeded in achieving benefits for Indigenous communities. In particular, the Committee was impressed by the successes of Heathgate Resources at Beverley and Cameco Corporation in Saskatchewan. The Committee strongly urges industry, governments and Indigenous communities themselves to continue to strive to ensure Aboriginal people benefit from uranium mining operations through employment, business and training opportunities.

To ensure adequate local community consultation, the Committee further recommends that a process be established whereby it and its successor committees be formally given access to new uranium mine sites, with customary powers of inquiry and report to the Parliament. This process should formally provide for affected local governments to nominate a person to liaise with the Committee about any community concerns **[Recommendation 7]**.

Chapter eleven: Impediments to the uranium industry's development

The chapter outlines the range of impediments to the uranium industry's development in Australia, summarising these under the headings of: general impediments to the industry; impediments to existing producers; impediments to junior exploration companies; and public perceptions of the uranium industry and nuclear power.

Industry presented a range of issues to the Committee, including:

- restrictions on uranium mining and exploration in some states;
- regulatory inconsistencies across jurisdictions;
- lack of government assistance;
- sovereign risk;
- inappropriate government scrutiny of sales contracts;
- transportation restrictions;
- labour and skills shortages;
- excessive reporting requirements;
- absence of infrastructure in some prospective mining areas;
- labour and skills shortages;
- geoscientific data;
- access to capital; and
- the opposing influence of other industries.

The Committee urges the Australian Government, through the Council of Australian Governments, seek to remedy these impediments **[Recommendation 9]**.

The Committee concludes that the principal impediment to the growth of the uranium industry in Australia remains the prohibition on uranium mining in some states and the lack of alignment between federal and state policy. The Committee insists that the current restrictions on uranium mining are illogical, inconsistent and anticompetitive. Restrictions have impeded investment in the industry, and have resulted in a loss of regional employment and wealth creation opportunities, royalties and tax receipts. The only beneficiaries of restrictions are the three existing producers and foreign competitors. State policies that prevent development of new uranium mines should be lifted and legislative restrictions on uranium mining and exploration should be repealed **[Recommendation 8]**.

Negative public perceptions of the uranium industry and misconceptions about the nature of the industry's operations were frequently cited, both by existing producers and by junior exploration companies, as key impediments to the industry's growth in Australia.

The Committee does not question the sincerity with which those people expressing 'moral outrage' at the very existence of the uranium industry hold their views. However, the Committee believes that these views are not informed by an accurate assessment of the benefits and risks associated with the industry. Misinformation and ignorance of the facts, as presented in evidence to the Committee, included: the failure to appreciate the true greenhouse benefits of nuclear power across the fuel cycle; nuclear power's safety record, which is far superior to all other major energy sources; massive overstatement of the known number of fatalities associated with the Chernobyl accident; the success of non-proliferation regimes; and the sophisticated management of waste, which is very small in volume compared with fossil fuel alternatives; and the international consensus in support of geologic repositories for disposal of high level waste. There is also a general refusal to acknowledge the immense energy density of uranium and its value in a world where demand for energy may triple by 2050. There is no acknowledgement that uranium is Australia's second largest energy export in thermal terms, or nuclear's part in addressing the global energy imbalance. Such views, although held by perhaps a minority of people, do influence policy and this impedes the development of the industry.

The Committee is convinced that while widespread misconceptions about the industry persist, the industry's growth will be impeded.

Factors that have contributed to negative perceptions of the industry have included the Australian public's lack of exposure to uranium mining and nuclear power in the past, which has led to a degree of ignorance about the industry and in turn created a climate in which myths and unfounded fears could be propagated. Ignorance and/or bias by sections of the teaching profession, and neglect of uranium and nuclear power from school and tertiary curricula may also have contributed. The opposition to uranium mining by environmental groups and some unions were also cited as factors in generating public antipathy to uranium mining and nuclear power.

The uranium industry consistently emphasised the need for improved public eduction about all aspects associated with uranium mining and nuclear power. The Committee concurs with this view. It is imperative that the benefits and risks associated with uranium mining and use of nuclear power be more widely understood among the Australian public. Any concerns and unfounded fears should be addressed. Moreover, opinion leaders in Australia, particularly members of parliaments and the media, need to be better informed and provided with a more balanced perspective on the industry and its merits.

To this end, accurate and objective information about the industry needs to be made available by a credible and authoritative source or sources. In particular, evidence pointed to the need for information on radiation and radioactive waste management.

The Committee concludes that public education and advocacy needs to be augmented and the Committee believes that both industry and Government must play a part. A communication strategy is therefore justified to address concerns the public may have and address areas of poor understanding. This information should also be provided to political leaders at all levels and the media **[Recommendation 11]**.

The Committee concedes that finding the right balance between transparency versus the right of the industry to have its reputation protected from undue criticism is a difficult balance to strike. The Committee is pleased to note the preparedness of the industry to comply with reporting standards as they currently stand.

The Committee believes that progress could be made if, in addition to maintaining the currently rigorous reporting requirements, regulators issued a brief assessment of the impacts of any incidents that occur. A simple classification system could be devised that states simply whether the incident has 'no impact', 'minimal impact' and so on. In this way, companies will continue to report incidents and satisfy the public's desire to be informed about the industry, while regulators' assessments will better communicate the seriousness of the impacts of any incidents that may occur. In this way, the Committee hopes that public understanding of the real impacts of uranium mining operations will be enhanced and companies will be somewhat protected from unfounded criticism **[Recommendation 10]**.

Chapter twelve: Value adding — fuel cycle services industries in Australia

The Committee's terms of reference and additional issues did not seek submissions relating to the possible domestic use of nuclear power or the question of establishing domestic fuel cycle services industries. However, a number of submitters volunteered opinions and information in relation to these matters. The Committee concludes its report with an overview of this evidence. The Committee also addresses itself to the skills base and research and development (R&D) activity to support Australia's current and possible future participation in the nuclear fuel cycle.

The Committee agrees that for Australia to possess such a large proportion of the world's uranium resources—approximately 40 per cent of the global total—and *not* to have taken up opportunities over the past 35 years to develop uranium enhancement industries is highly regrettable.

There have been several missed opportunities, notably a proposal to develop a commercial uranium enrichment industry in Australia by a consortium of Australian companies, the Uranium Enrichment Group of Australia (EUGA)—BHP, CSR, Peko-Wallsend and WMC—in the early 1980s. This proposal was terminated following a change of Federal Government.

In addition to the foregone export earnings and the missed opportunities to develop sophisticated technologies and an associated domestic knowledge base, the failure to press ahead with the development of fuel cycle services industries in Australia has wasted a significant public R&D investment.

In addition to domestic economic and technological benefits, increased involvement by Australia in the fuel cycle could have non-proliferation and security advantages. Indeed, as argued by some submitters, fuel cycle facilities could well be established in Australia on a multination basis, in accordance with the IAEA's expert advisory group recommendations outlined in chapter seven, thereby providing a high level of transparency for regional neighbours and the international community generally. Such a development would have clear global non-proliferation benefits, while also allowing Australia the opportunity to extract greater returns from its immense uranium resource endowment, to develop sophisticated technologies and to expand its national skills base.

The Committee urges that state governments re-evaluate the merits of the eventual establishment of such industries within their jurisdictions, particularly in the uranium rich jurisdictions of South Australia, the Northern Territory and Western Australia. Furthermore, the Committee wishes to encourage Australian companies, such as those that participated in the UEGA enrichment industry proposals of the early 1980s, to actively consider the opportunities such developments might present in the future.

The Committee concludes that, by virtue of its highly suitable geology and political stability, Australia could also play an important role at the back-end of the fuel cycle in waste storage and disposal. Again, such a development could be highly profitable, as well as possibly providing global security benefits. However, as noted in chapter five, the US Global Nuclear Energy Partnership initiative proposes to revolutionise spent fuel management and this could obviate the need for geologic repositories altogether.

The Committee has no in-principle objection to the use of nuclear power in Australia and believes that, subject to appropriate regulatory oversight, utilities that choose to construct nuclear power plants in Australia should be permitted to do so. There would be clear greenhouse gas emission and other technological and potential economic benefits from doing so.

Nuclear power may not be immediately competitive in the Australian context, due to the quantity and quality of Australia's coal resources (and that carbon emissions are currently not priced). However, the Committee believes that if Federal and state governments continue to provide a range of incentives to achieve low carbon emissions, for example by subsidising renewables such as wind, then governments should not discriminate against nuclear power—which will achieve very low emissions but also generate baseload power, unlike the currently subsidised renewable alternatives.

Even if the domestic use of nuclear energy and uranium enhancement industries in Australia are not established in the near future, the Committee recommends that the Australian and state governments commence examining best practice licensing and regulatory frameworks that could be put in place to facilitate the eventual establishment of such facilities **[Recommendation 12]**.

The Committee is concerned that, with the closure in 1988 of Australia's sole university school of nuclear engineering, Australia no longer has an indigenous source of trained personnel in the nuclear field. The Committee concludes that the Australian Government should seek to progressively rebuild Australia's nuclear skills base. Among other initiatives, the Government should broaden ANSTO's research and development mandate, so that it is once again able to undertake physical laboratory studies of aspects of the nuclear fuel cycle that may be of future benefit to Australia and Australian industry. Consideration should also be given to re-establishing at least one university school of nuclear engineering **[Recommendation 13]**.

Finally, the Committee is persuaded of the immense potential benefit that fusion energy represents for the world and, specifically, the potential benefits for Australian science and industry from involvement in the International Thermonuclear Experimental Reactor (ITER) project. The Committee believes that involvement in this experimentation is simply too important for the nation to miss, even if the introduction of fusion power is indeed many decades off. Accordingly, the Committee recommends that Australia secure formal involvement in the ITER project and seek to better coordinate its research for fusion energy across the various fields and disciplines in Australia **[Recommendation 14]**.

1

Introduction

Referral of the inquiry

1.1 On 15 March 2005 the Minister for Industry, Tourism and Resources, the Hon Ian Macfarlane MP, wrote to the House of Representatives Standing Committee on Industry and Resources (the Committee) asking it to conduct a case study into the strategic importance of Australia's uranium resources, as part of a broader inquiry into the development of Australia's non-fossil fuel energy industry. The terms of reference for the case study are provided on page xxi of the report.

Conduct of the case study

1.2 A media release announcing the inquiry was issued on 17 March 2005. The Committee's terms of reference were advertised and written submissions invited in the *Australian Financial Review* on 1 April 2005, *The Australian* on 20 April 2005, *Australia's Mining Monthly* in May 2005, *The AusIMM Bulletin* in May/June 2005, and on-line through *MiningNews.Net* during April 2005.

1.3 The Committee wrote to 180 organisations, companies and individuals inviting them to make submissions to the inquiry. These included major uranium and coal mining companies, junior uranium exploration companies, industry and professional associations, banking and financial institutions, environmental organisations, unions, Aboriginal organisations, and Government scientific agencies. The Committee invited submissions from all state and territory governments.

1.4 In its letters inviting submissions, the Committee also indicated that it would welcome comments in relation to six additional issues, as follows:

- whole of life cycle waste management assessment of the uranium industry, including radioactive waste management at mine sites in Australia, and nuclear waste management overseas consequent to use of Australian exported uranium;
- the adequacy of social impact assessment, consultation and approval processes with traditional owners and affected Aboriginal people in relation to uranium mining resource projects;
- examination of health risks to workers and to the public from exposure to ionising radiation from uranium mining;
- adequacy of regulation of uranium mining by the Commonwealth;
- assessing the extent of federal subsidies, rebates and other mechanisms used to facilitate uranium mining and resource development; and
- the effectiveness of safeguards regimes in addressing the proliferation of fissile material, the potential diversion of Australian obligate fissile materials, and the potential for Australian obligate radioactive materials to be used in 'dirty bombs'.

1.5 The Committee received 87 written submissions and 19 supplementary submissions, which are listed at Appendix A. The Committee also received 93 exhibits, which included ancillary material provided by witnesses at public hearings and various technical documents. A list of the exhibits is at Appendix B.

1.6 Three petition letters were received from seventeen individuals expressing opposition to further uranium mining. These were received by the Committee as three submissions, with the names of the individuals expressing the views listed under the respective submission in Appendix A.

1.7 Public hearings were conducted by the Committee in Sydney, Melbourne, Perth, Darwin and Canberra from August 2005 to March 2006. In total, 87 witnesses were examined at 13 public hearings. The dates and locations of the hearings, together with the names of witnesses who appeared before the Committee is at Appendix C.

1.8 Inspections were held by the Committee at the three uranium mines that are currently operating—Olympic Dam and Beverley in South Australia and Ranger in the Northern Territory.

1.9 Access to the published submissions to the inquiry, transcripts of evidence taken at public hearings and an electronic copy of the report is available on the internet from the Committee's web site:

http://www.aph.gov.au/house/committee/isr/uranium/index.htm

Structure of the report and principal findings

1.10 In addition to this introductory chapter, the report comprises 11 chapters. The contents and principal findings of the chapters are summarised as follows.

1.11 The Committee's conclusions and recommendations are also summarised in a *key messages* section at the beginning of each chapter and in the *conclusions* section at the end of each chapter.

Chapter two: Uranium: Demand and Supply

1.12 The Committee commences the report by considering the global demand and supply of uranium in the context of world electricity consumption trends and nuclear power's share in the electricity generation mix. The Committee provides a summary of forecasts for world nuclear generating capacity and associated uranium requirements. Competing views on the outlook for new nuclear power plant construction are then considered, followed by an assessment of the role of existing plant performance in influencing the demand for uranium.

1.13 Uranium supply is provided by a combination of primary (mine) production and secondary sources (e.g. inventories held by utilities and ex-military material). The contribution of each part is discussed. The Committee then considers the argument that world uranium resources are insufficient to support an expansion of nuclear power and, hence, represent only a temporary response to the problem of climate change.

1.14 The Committee concludes the chapter with an assessment of the implications of the supply/demand balance for further mine production and the potential for Australia's uranium production to expand to meet requirements.

1.15 The Committee concludes that new nuclear build combined with improved reactor performance and operating life extensions are likely to outweigh reactor retirements in the years ahead, thereby increasing projected uranium requirements. Importantly, secondary supplies (which provide some 35 per cent of the market) are also declining, leading to an increased requirement for uranium mine production. Dramatic increases in the uranium spot price are stimulating new uranium exploration activity.

1.16 The chapter commences with an overview of the nuclear fuel cycle, which establishes a context for the discussion in subsequent chapters of matters including greenhouse gas emissions, waste, safety and proliferation risks associated with nuclear power generation.

Chapter three: Australia's uranium resources, production and exploration

1.17 The chapter provides a detailed overview of Australia's uranium resources, mine production and exploration for uranium.

1.18 Australia possesses 38 per cent of the world's total Identified Resources of uranium recoverable at low cost. According to company reports, Australia's known uranium deposits currently contain a total of over 2 million tonnes of uranium oxide in in-ground resources. The in-situ value of this resource at spot market prices prevailing in June 2006 was over A$270 billion.

1.19 The Committee was pleased to note record uranium production and exports for Australia in calendar year 2005. Production across the three operational mines (Ranger, Olympic Dam and Beverley) was 11 222 tonnes of uranium oxide (t U_3O_8) and exports were 12 360 t U_3O_8. Uranium exports also earned a record $573 million in 2005.

1.20 Some 75 per cent of Australia's total Identified Resources of uranium are located in South Australia, but significant deposits are also located in the Northern Territory, Western Australia and Queensland.

1.21 Olympic Dam in South Australia contains 26 per cent of the world's low cost uranium resources and is the world's largest uranium deposit. A proposal to expand Olympic Dam would see uranium production from the mine treble to 15 000 tonnes of uranium oxide per year, which would make Olympic Dam and its owners, BHP Billiton Ltd, by far the world's largest uranium producer.

1.22 The increase in uranium spot price and the anticipated decline in secondary supplies have stimulated a resurgence in exploration activity and expenditure in Australia.

1.23 While there has been a trend of increasing exploration expenditure since early 2003, there has been relatively little exploration for uranium over the past two decades and Australia's known uranium resources generally reflect exploration efforts that took place 30 years ago. It is likely that the size of Australia's known uranium resources significantly understates the potential resource base and there is great potential for new and significant discoveries.

1.24 In its previous report, which addressed impediments to exploration, the Committee accepted that future world-class uranium deposits are likely to be located at greater depths than those hitherto discovered. It was concluded that this will require large injections of exploration investment capital to overcome the technical challenges of locating bedrock deposits. These observations reinforce the need to ensure that junior companies, which are generally efficient explorers, are appropriately assisted to discover Australia's future world-class uranium and other mineral deposits. The Committee is convinced of the merits of flow-through share schemes and repeats the recommendation contained in its previous report.

1.25 To assist in the discovery of new world-class uranium deposits the Committee recommends that Geoscience Australia be provided with additional funding to develop and deploy techniques to provide precompetitive geoscience of prospective areas, in order to assist in the discovery of new world-class uranium and other mineral deposits located under cover and at depth.

Chapter four: Greenhouse gas emissions and nuclear power

1.26 The chapter addresses the greenhouse gas emissions avoided by the use of nuclear power, emissions across the whole nuclear fuel cycle, the contribution from renewable energy sources, and the relative economic attractiveness of nuclear power for baseload power generation.

1.27 The Committee concludes that nuclear power unquestionably makes a significant contribution to the mitigation of greenhouse gas (GHG) emissions—nuclear power plants currently save some 10 per cent of total carbon dioxide (CO_2) emissions from world energy use. This represents an immense saving of GHG emissions that would otherwise be contributing to global warming. If the world were not using nuclear power plants, emissions of CO_2 would be some 2.5 billion tonnes higher per year.

1.28 An important consideration in assessing nuclear power's viability as a GHG emission mitigation option relates to the economic competitiveness of nuclear power relative to other baseload alternatives. Evidence suggests that nuclear power plants have higher capital/construction costs than either coal or gas plants, which are characterised by mid-range and low capital costs respectively. However, nuclear plants have low fuel, operating and maintenance costs relative to the fossil fuel alternatives.

1.29 A range of recent authoritative studies have concluded that, in many industrialised countries, nuclear power is competitive with gas and coal-fired electricity generation, even without incorporating an additional cost for the carbon emissions from the fossil fuelled plants.

Chapter five: Radioactive waste

1.30 It was alleged in evidence that there remain three unresolved issues associated with the nuclear fuel cycle and its industries that, in the view of some submitters, are such as to justify a winding back of uranium mining and an eventual end to the use of nuclear power worldwide. These issues relate to the:

- generation and management of *radioactive waste* across the nuclear fuel cycle, principally waste from the operation of nuclear reactors, but also waste from uranium mines;
- *safety* of the fuel cycle, particularly the operation of nuclear reactors and the risks to health from fuel cycle industries, including uranium mining; and
- risk of *proliferation* of nuclear materials and technologies, and their diversion for use in weapons programs.

1.31 Chapter five and the following three chapters examine the evidence presented to the Committee in relation to each of these three key issues.

1.32 Chapter five addresses the management of radioactive waste generated across the nuclear fuel cycle, from uranium mining to the decommissioning of nuclear power plants.

1.33 The Committee concludes that the radioactive wastes which are produced at each stage of the nuclear fuel cycle have, since the inception of the civil nuclear power industry 50 years ago, been responsibly managed. There are proven technologies for the management of all types of radioactive waste.

1.34 The Committee finds that nuclear power deals with its waste more explicitly and transparently than many other sources of energy. The Committee notes that high level radioactive waste has several features which lends itself to ease of management: very small volumes (12 000 tonnes per year worldwide); the radioactivity is contained in the spent fuel assemblies; it decays at a predictable rate; and is amenable to separation, encapsulation and isolation. Moreover, the nuclear power industry significantly contributes to the cost of its waste management through levies imposed on utilities.

1.35 This is in sharp contrast to the wastes produced by fossil fuels, which are not contained or managed, involve enormous volumes and a range of toxic pollutants that do not decay. Moreover, the cost of the environmental externalities these energy sources create are generally not factored into the price of the electricity generated.

Chapter six: Safety of the nuclear fuel cycle

1.36 The chapter examines the second 'unresolved' issue associated with the civil nuclear power industry—the safety of nuclear fuel cycle facilities, and particularly the health risks to workers and to the public from exposure to radiation from uranium mining and nuclear power plants.

1.37 The chapter presents evidence in relation to the following themes in turn: the health effects from exposure to ionising radiation and the current international standards for control of radiation exposure; regulation for radiation protection in Australia; safety and health issues associated with the uranium mining industry in Australia; radiation exposure from the whole nuclear fuel cycle; nuclear safety; and radiation and public perceptions.

1.38 The Committee concludes that the nuclear power industry has by far the best safety record of all major energy industries, including coal, oil, natural gas, liquefied petroleum gas and hydro. Notwithstanding the tragedy of the Chernobyl accident, which has been the only accident to a commercial nuclear power plant that has resulted in loss of life, nuclear power's safety record is unrivalled by any other major energy source.

1.39 The total average effective radiation dose received by the world population from natural sources of radiation (i.e. 'natural background radiation') is 2.4 millisieverts (mSv) per year. In contrast, the total average effective dose to monitored workers across the whole nuclear fuel cycle (including uranium mining and milling) is 1.75 mSv per year. The maximum average annual radiation dose allowed for a uranium miner is currently set at 20 mSv. The actual dose received by workers at Australian uranium mines is well under half this level. The radiation exposure for the public in the vicinity of the mines is a small fraction of the prescribed limit for members of the public.

1.40 To provide greater assurance to uranium industry workers and the public at large, and also to definitively answer claims—which the Committee is confident are entirely mistaken—that current radiation exposures are harming workers, the Committee recommends the establishment of:

- a national radiation dose register for occupationally exposed workers; and
- a system of long-term monitoring of the health outcomes for workers occupationally exposed to radiation in uranium mining, associated industries and nuclear facilities.

Chapter seven: The global non-proliferation regime

1.41 In this and the following chapter the Committee addresses the third objection to the use of nuclear power—nuclear proliferation and the effectiveness of safeguards regimes.

1.42 The chapter first introduces the concept of proliferation and explains how some technologies required in the civil nuclear fuel cycle also have military uses. The Committee describes the current global non-proliferation regime, the key elements of which are the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) and the safeguards activities of the International Atomic Energy Agency (IAEA).

1.43 The Committee concludes that the global safeguards regime has indeed been remarkably successful in limiting the proliferation of nuclear weapons. While the Committee believes that most alleged deficiencies in the regime are without substance, it notes that the regime is now facing several challenges which must be met.

1.44 The Committee welcomes the commendable range of efforts the Australian Government is undertaking to advance non-proliferation objectives but recommends that further action be taken, including, inter alia: redoubling efforts to encourage adoption by other countries of the Additional Protocol to the NPT; seeking the development of criteria for assessing the international acceptability of proposed sensitive projects; and examining the resourcing of the IAEA's safeguards program.

Chapter eight: Australia's bilateral safeguards

1.45 The chapter considers the adequacy and effectiveness of Australia's safeguards policy and the bilateral safeguards agreements it enters into with countries wishing to purchase Australian uranium.

1.46 The chapter commences with an overview of the safeguards policy and the principal conditions for the use of Australian Obligated Nuclear Material (AONM) set out in the bilateral agreements. Four main criticisms were made in evidence of the safeguards policy and agreements, which the Committee considers in turn, along with rebuttals from the Australian Safeguards and Non-Proliferation Office.

1.47 The chapter then considers several other proliferation concerns and allegations raised by submitters, and concludes with a discussion of nuclear security, including the possible malicious use of radioactive sources in so-called 'dirty bombs' and efforts to prevent nuclear terrorism.

1.48 While the Committee notes that it simply cannot be absolutely guaranteed that diversion of AONM for use in weapons could never occur at some point in the future, nevertheless the Committee is satisfied that Australia's safeguards policy has been effective to date. The Committee concludes that the requirements in safeguards agreements are adequate and can see no reason for imposing additional requirements at this time.

1.49 The Committee supports the Australian Government's decision to permit exports of uranium to China.

1.50 The Committee belives that the US-India nuclear cooperation agreement will have a number of important non-proliferation benefits, including that it will expand the application of IAEA safeguards in India and allow the IAEA enhanced access rights. However, while there are sound reasons to allow an exception to Australia's exports policy in order to permit uranium sales to India, including its record as a non-proliferator, the

Committee does not wish to make a recommendation on the matter. Maintaining the integrity of the non-proliferation regime must remain the top priority and guiding principle for Australia's uranium exports policy and the Committee hopes that a bipartisan position on this issue can be developed.

Chapter nine: Strategic importance of Australia's uranium resources

1.51 In addition to its greenhouse gas emission benefits, which were discussed in chapter four, evidence presented to the Committee suggested that the strategic importance of Australia's uranium resources derives from the:

- significance of the resource as one of Australia's major energy exports;
- energy security benefits that uranium can provide those countries that choose to adopt nuclear power;
- potential for Australia's uranium exports to assist in addressing the global energy imbalance;
- economic benefits that may be obtained from uranium mining, particularly for state economies and regional communities;
- economic significance of Australia's undeveloped uranium resources; and
- Australia's role as a major uranium exporter in the global nuclear fuel cycle.

The chapter considers each of these points in turn.

1.52 Among other findings, the Committee notes that uranium is Australia's second largest energy export in terms of contained energy content. Uranium is an immensely concentrated source of energy—one tonne of uranium oxide generates the same amount of energy as 20 000 tonnes of black coal. The uranium produced from just one of Australia's mines each year—Ranger, in the Northern Territory—contains sufficient energy to provide for 80 per cent of Australia's total annual electricity requirements, or all of Taiwan's electricity needs for a year.

1.53 In addition, the Committee concludes that while Australia is well endowed with energy resources for its own needs, other countries are not so fortunate. These include developing countries such as China. As a matter of energy justice, the Committee believes that Australia should not deny countries who wish to use nuclear power in a responsible manner the benefits from doing so. Neither should Australia refuse to export its uranium to assist in addressing the global energy imbalance and the disparity in living standards associated with this global inequity.

1.54 Moreover, expanded mining and exports of uranium will have economic and other benefits for the nation, the states that permit uranium resources to be developed and the regional communities supporting the mines.

Chapter ten: Uranium industry regulation and impacts on Aboriginal communities

1.55 The chapter examines the current structure and regulatory environment of the uranium mining sector (noting the work that has been undertaken by other inquiries and reviews on these issues). The chapter commences with a description of the current regulatory environment, focussing on the Australian Government's role. This is followed by sections detailing the industry's assessment of the current regulatory regime, criticisms of the regulatory environment and consultation with Traditional Owners and the social impacts of uranium mining on Aboriginal communities.

1.56 Criticisms of perceived failings of the current regulatory regime by those opposed to uranium mining generally relate to the adequacy of environmental protection from the impacts of uranium mining. However, the Committee concludes that while deficient regulation and poor mining practices in past decades have led to ongoing rehabilitation problems at former uranium mine sites and recommends that further funding be provided to complete this rehabilitation, it concludes that current regulation is entirely adequate.

1.57 The Committee notes, for example, that the Ranger operation in the Northern Territory is required to meet among the most rigorous reporting regimes in the country. Ranger is monitored and regulated by a range of independent bodies. The Committee notes that there has been no harm to the Kakadu National Park from the mining operations at Ranger.

1.58 The Committee concludes that while there are a number of impediments to increasing Aboriginal engagement in uranium mining, industry, governments and Indigenous communities themselves should seek to emulate the examples of mining operations, both in Australia and abroad, that have succeeded in achieving employment, business and training benefits for Indigenous communities.

Chapter eleven: Impediments to the uranium industry's development

1.59 The chapter summarises the impediments to the uranium industry's growth in Australia.

1.60 The Committee finds that the principal impediment to the growth of the uranium industry in Australia remains the prohibition on uranium mining in some states and the lack of alignment between federal and state policy. The Committee urges state governments to reconsider their opposition to uranium mining and to abolish legislative restrictions where these exist. The Committee also recommends that governments address the range of other impediments to the development of the industry.

1.61 In addition, and as described in preceding chapters of the report, the Committee believes that there are widespread misconceptions associated with uranium mining and nuclear power. While these misconceptions persist, the industry's growth is likely to be impeded. The Committee concludes that it is vital that the concerns of the public be responded to. Information should be communicated both to the general public and opinion leaders that eases concerns and addresses areas of poor understanding.

Chapter twelve: Value adding — fuel cycle services industries, nuclear power, skills and training in Australia

1.62 The chapter provides an overview of evidence presented in relation to the possible domestic use of nuclear power and the question of establishing domestic fuel cycle services industries. The Committee also addresses itself to the skills base and research and development (R&D) activity to support Australia's current and possible future participation in the nuclear fuel cycle.

1.63 The Committee regrets that Australia has missed several opportunities to develop industries based on upgrading Australia's uranium resources for export. In addition to the foregone export earnings and the missed opportunities to develop sophisticated technologies and an associated domestic expertise, the failure to press ahead with the development of fuel cycle services industries in Australia has wasted a significant public R&D investment.

1.64 Australia possesses some 40 per cent of the world's uranium, perhaps more. By virtue of this immense resource endowment, Australia has a very strong economic interest in, and justification for, seeking to add value to its uranium resources prior to export. The Committee concludes that such a development would allow Australia the opportunity to extract greater returns from its resource endowment, to develop sophisticated technologies and to expand its national skills base.

1.65 Although the Committee acknowledges that nuclear power may not be immediately competitive in the Australian context, due to the quantity and quality of coal resources (and that carbon emissions are currently not priced), the Committee has no in-principle objection to the use of nuclear power in Australia and believes that, subject to appropriate regulatory oversight, utilities that choose to construct nuclear power plants in Australia should be permitted to do so.

1.66 To facilitate the possible eventual development of domestic fuel cycle facilities, the Committee recommends that steps should now be taken to develop a licensing and regulatory framework to support the possible eventual establishment of such facilities in Australia. The Committee also urges that Government seek to progressively rebuild Australia's nuclear skills base which has been dissipated.

1.67 The chapter concludes with some supplementary remarks from the Opposition members of the Committee in relation to the domestic use of nuclear power and uranium enrichment.

Appreciation

1.68 The Committee wishes to thank those who contributed to the uranium case study, particularly the witnesses who were prepared to travel in order to appear before the Committee. The Committee also thanks the companies that facilitated its inspections of the currently operating uranium mines—BHP Billiton Ltd, Energy Resources of Australia Ltd and Heathgate Resources Pty Ltd. The Committee appreciated the willingness of the Northern Territory Government to have its officials appear before the Committee at its public hearing in Darwin.

2

Uranium: Demand and Supply

The civilian nuclear industry is poised for world-wide expansion. Rapidly growing demand for electricity, the uncertainty of natural gas supply and price, soaring prices for oil, concern for air pollution and the immense challenge of lowering greenhouse emissions, are all driving a fresh look at nuclear power. At the same time, fading memories of Three Mile Island and Chernobyl is increasing confidence in the safety of new reactor designs. So the prospect, after a long hiatus, of new nuclear power construction is real, with new interest stirring in countries throughout the world.[1]

Australia is already a significant supplier of uranium – yet the growing demand is providing an unparalleled opportunity for Australia to be the dominant supplier of a crucial global commodity.[2]

1 Mr Lance Joseph (Australian Governor on the Board of the International Atomic Energy Agency 1997–2000), *Submission no. 71*, p. 1.

2 Nova Energy Ltd, *Submission no. 50*, p. 8.

Key messages —

- **Demand for uranium is a function of nuclear generating capacity in operation worldwide, combined with the operational characteristics of reactors and fuel management policies of utilities.**
- **There are currently 441 commercial nuclear power reactors operating in 31 countries. In 2005, nuclear reactors generated 2 626 billion kilowatt-hours of electricity, representing approximately 16 per cent of world electricity production. Some 27 nuclear reactors are currently under construction and a further 38 are planned or on order worldwide.**
- **Expectations of increased world nuclear generating capacity and demand for uranium are underpinned by:**
  - ⇒ **forecasts for growth in world electricity demand, particularly in China and India;**
  - ⇒ **improved performance of existing nuclear power plants and operating life extensions;**
  - ⇒ **plans for significant new nuclear build in several countries and renewed interest in nuclear energy among some industrialised nations; and**
  - ⇒ **the desire for security of fuel supplies and heightened concerns about greenhouse gas emissions from the electricity sector.**
- **New reactor construction combined with capacity upgrades and life extensions of existing reactors are projected to outweigh reactor shutdowns over the next two decades, so that world nuclear capacity will continue to increase and thereby increase projected uranium requirements.**
- **Several forecasts for world nuclear generating capacity and uranium requirements have been published. A conservative forecast by the IAEA and OECD-NEA predicts that nuclear generating capacity will grow to 448 gigawatts electrical by 2025, representing a 22 per cent increase on current capacity. This would see annual uranium requirements rise to 82 275 tonnes by 2025, also representing a 22 per cent increase on the 2004 requirements of 67 430 tonnes.**
- **Uranium mine production meets only 65 per cent of world reactor requirements. The balance of requirements are met by secondary sources of supply, notably inventories held by utilities and ex-military material. Secondary supplies are expected to decline over**

coming years and the anticipated tightness in supply has been reflected in a six-fold increase in the uranium spot market price since December 2000.

- **A significant source of secondary supply has been provided through the down-blending of highly enriched uranium (HEU) removed from weapons and military stockpiles in both the Russian Federation and the USA. To date, more than 10 460 nuclear warheads have been converted into fuel to generate electricity through a Russia-USA HEU Purchase Agreement. This agreement will run to 2013 and is unlikely to be renewed.**
- **Uranium mine production must expand to meet a larger share of reactor requirements as secondary supplies are exhausted.**
- **Australia possesses 36 per cent the world's low cost uranium resources, twice the resources of Canada. However, Australia accounts for only 23 per cent of world production and lags substantially behind Canada. Provided that impediments to the industry's growth are eliminated, there is great potential for Australia to expand production and become the world's premier supplier of uranium.**
- **Sufficient uranium resources exist and are likely to be discovered to support significant growth in nuclear capacity in the longer-term.**
- **Total Conventional Resources of uranium, amounting to some 14.8 million tonnes of uranium, are sufficient to fuel 270 years of nuclear electricity generation at current rates of consumption. There is considerable potential for the discovery of additional economic resources, particularly as higher uranium prices are now stimulating increased exploration. Utilisation of Unconventional Resources, such as the uranium in phosphates, would extend supply to over 670 years at current rates of consumption.**
- **Wider deployment of advanced reactor technologies, particularly Fast Neutron Reactors, and alternate fuel cycles have the potential to extend the supply of uranium resources for thousands of years.**

Introduction

2.1 The Committee commences the report of its inquiry into the strategic importance of Australia's uranium resources by considering the global demand and supply of uranium in the context of world electricity consumption trends and nuclear power's share in the electricity generation mix.

2.2 The Committee provides a summary of forecasts for world nuclear generating capacity and associated uranium requirements. Competing views on the outlook for new nuclear power plant construction are then considered, followed by an assessment of the role of existing plant performance in influencing the demand for uranium.

2.3 Uranium supply is provided by a combination of primary (mine) production and secondary sources. The contribution of each part is discussed. The Committee then considers the argument that world uranium resources are insufficient to support an expansion of nuclear power and, hence, represent only a temporary response to the problem of climate change.

2.4 The Committee concludes the chapter with an assessment of the implications of the supply/demand balance for further mine production and the potential for Australia's uranium production to expand to meet requirements.

2.5 The chapter commences with an overview of the nuclear fuel cycle, which establishes a context for the discussion in subsequent chapters of matters including greenhouse gas emissions, waste, safety and proliferation risks associated with nuclear power generation.

What is uranium?

2.6 Uranium is a radioactive metallic element, naturally occurring in most rocks, soil and in the ocean. In its pure form, uranium is a silvery white metal of very high density—1.7 times more dense than lead. Uranium is found as an oxide or complex salt in minerals such as pitchblende, uraninite and brannerite. Concentrations of uranium also occur in substances such as phosphate rock deposits and minerals such as lignite.[3]

2.7 Uranium is 500 times more abundant in the Earth's crust than gold and as common as tin.[4] While uranium can be found almost everywhere, including in seawater, concentrated uranium ores are found in relatively few places, usually in hard rock or sandstone. Concentrations of uranium that are economic to mine for use as nuclear fuel are considered orebodies.[5] Economically extractable concentrations of uranium occur in

3 e-CBD Pty Ltd, *Australian Uranium*, 'About Uranium', viewed 16 December 2005, <http://www.australianuranium.com.au/about-uranium.html>.

4 Uranium's average abundance in the Earth's crust is 2.7 parts per million (ppm) while the concentration in sea water is 0.003 ppm.

5 According to the Uranium Information Centre (UIC), the typical concentration of uranium in high-grade ore is 20 000 ppm, or 2 per cent uranium. Low grade ores are

more than a dozen different deposit types in a wide range of geological settings.[6]

2.8 Uranium has two major peaceful purposes: as the fuel in nuclear power reactors to generate electricity, and for the manufacture of radioisotopes for medical and other applications.

2.9 Naturally occurring uranium exists as a mix of three isotopes in the following proportions: U-234 (0.01%), U-235 (0.71%) and U-238 (99.28%).[7] Uranium-235 has a unique property in that it is the only naturally-occurring fissionable isotope. That is, the nucleus of the U-235 atom is capable of splitting into two parts when hit by a neutron. As the atom splits, a large amount of energy is released as heat and several new neutrons are emitted. This process is called fission. The neutrons emitted from the split nucleus may then cause other U-235 atoms to split, thus giving rise to a chain reaction if the mass of fissionable material exceeds a certain minimum amount known as the critical mass. The process of fission is harnessed in nuclear power generation, which is described in the following section, and in nuclear weapons.[8]

2.10 Following mining and milling, uranium metal (U) is sold as uranium oxide concentrate (UOC) which is comprised of uranium oxide (U_3O_8) and small quantities of impurities. Until 1970 uranium mine product was sold in the form of 'yellowcake' (ammonium diuranate), which is the penultimate uranium compound in U_3O_8 production. Following mining and milling, uranium enters the remaining stages of the nuclear fuel cycle, which are described below.

2.11 Uranium demand and supply are generally expressed in terms of tonnes U, while uranium mine production, ore reserves, ore grades and prices are commonly described in terms of U_3O_8. Uranium prices are generally

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1 000 ppm, or 0.1 per cent uranium. See: UIC, *Supply of Uranium*, Nuclear Issues Briefing Paper No. 75, viewed 7 June 2006, <http://www.uic.com.au/nip75.htm>.

6 World Nuclear Association (WNA), *Can Uranium Supplies Sustain the Global Nuclear Renaissance?*, WNA, London, 2005, p. 3.

7 An atom, which is the smallest particle into which an element can be divided chemically, consists of a nucleus of protons and neutrons, surrounded by a cloud of electrons. The number of protons in the nucleus determines what element the atom represents (92 in the case of uranium). Isotopes occur where atoms of the same element have different numbers of neutrons. That is, isotopes are nuclides (or 'nuclear species' of the same element) with the same number of protons, but different numbers of neutrons. For example, U-235 has 92 protons and 143 neutrons, while U-238 has 92 protons and 146 neutrons.

8 UIC, *Submission no. 12*, pp. 18–22; Minerals Council of Australia (MCA), *Commodity Information Sheets: Uranium*, Australian Atlas of Mineral Resources, Mines and Processing Centres, Geoscience Australia (GA), MCA and the Australian Government Department of Industry, Tourism and Resources, Canberra, 2003, viewed 30 May 2005, <www.australianminesatlas.gov.au/info/factsheets/uranium.jsp>.

expressed in terms of US dollars per pound U_3O_8. The glossary of this report contains definitions of uranium production and other mining terminology.[9]

2.12 Uranium was first recognised as a potential energy source by Ernest Rutherford in 1904 and first used as nuclear fuel in 1942. The first nuclear reactor to produce electricity was in Idaho, USA in December 1951. In 1954 the world's first nuclear powered electricity generator commenced operation at Obninsk in Russia, with other early generators at Calder Hall, England (1956) and Pennsylvania, USA (1957).[10]

The nuclear fuel cycle

2.13 The civil nuclear fuel cycle refers to the sequence of processes, from uranium mining through to final disposal of waste materials, associated with the production of electricity from nuclear reactions. The main stages in the fuel cycle are:

- mining and milling of the uranium ore;
- conversion and enrichment of the uranium;
- fuel fabrication to suit the requirements of reactors;
- fission in a reactor for the generation of power, or production of radioisotopes (for medical, industrial or research purposes);
- reprocessing of the used fuel elements; and
- disposal and storage of wastes.

2.14 In Australia, the fuel cycle is undertaken to the stage of uranium milling. A description of each of the stages, submitted by the Uranium Information Centre (UIC), follows.[11]

2.15 There are two common types of nuclear fuel cycle. The 'closed' nuclear fuel cycle, which is illustrated in figure 2.1, includes the reprocessing of used fuel whereby uranium and plutonium are separated and recycled into new fuel elements. The 'open' (or once-through) fuel cycle excludes reprocessing and all the used fuel is treated as waste for disposal.[12]

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9 Dr Donald Perkin, *Exhibit no. 3, The significance of uranium deposits through time*.

10 WNA, *Outline History of Nuclear Energy*, WNA, London, 2005, viewed 31 March 2006, <http://world-nuclear.org/info/inf54.htm>.

11 UIC, *loc. cit*.

12 International Atomic Energy Agency (IAEA), *Country Nuclear Fuel Cycle Profiles*, IAEA, Vienna, 2001, p. 1.

Uranium mining

2.16 Both excavation and in situ techniques are used to recover uranium. Excavation may involve underground and open pit methods.

2.17 In general, open pit mining is used where deposits are close to the surface and underground mining is used for deep deposits, typically greater than 120 metres deep. Open pit mines require large surface excavations, larger than the size of the ore deposit, since the walls of the pit must be sloped to prevent collapse. As a result, the quantity of material that must be removed to secure access to the ore may be large. Underground mines have relatively small surface disturbance and the quantity of material that must be removed to gain access to the ore is considerably less than in the case of an open pit mine.

2.18 An increasing proportion of the world's uranium now comes from in situ leaching (ISL), where groundwater with added peroxide is circulated through a very porous orebody to dissolve the uranium and pump it to the surface. Depending on the nature of the host and enclosing rocks, ISL may use slightly acid or alkaline solutions to keep the uranium in solution. The uranium is then recovered from the solution in a conventional mill.

2.19 The decision as to which mining method to use for a particular deposit is governed by the nature of the orebody, safety, environmental and economic considerations. In the case of underground uranium mines, special precautions, consisting primarily of increased ventilation, are required to protect against airborne radiation exposure.

Uranium milling

2.20 Milling, which is generally carried out close to a uranium mine, extracts the uranium from the ore. Most mining facilities include a mill, although where mines are close together, one mill may process the ore from several mines.

2.21 In a mill, uranium is extracted from the crushed and ground-up ore by leaching, in which either a strong acid (usually sulphuric acid) or a strong alkaline solution is used to dissolve the uranium. The uranium is then removed from this solution and precipitated. The bright yellow powder produced by this process is referred to as 'yellowcake'. The yellowcake is then dried and usually heated to produce a fine black powder containing over 98 per cent U_3O_8, which is then packed in 205-litre drums and shipped as UOC. Typically, 70 to 90 per cent of the uranium metal in the original ore is recovered in the milling process. The original ore itself may contain as little as 0.1 per cent uranium. The UOC usually contains small quantities of impurities such as sulphur, silicon and zircon.

2.22 The remainder of the ore, containing most of the radioactivity and nearly all the rock material, becomes tailings, which are placed in engineered facilities near the mine. These facilities are referred to as tailings dams. Tailings contain long-lived radioactive materials in low concentrations and toxic materials such as heavy metals. However, the total quantity of radioactive elements is less than in the original ore, and their collective radioactivity will be much shorter-lived. These materials are isolated from the environment for the period necessary to allow their radioactivity to reduce to background levels.

2.23 When mining and milling has been completed the tailings are covered with clay and topsoil to allow vegetation to be established and to keep radiation levels to the normal background value experienced near a uranium orebody. Alternatively, tailings may be filtered to a dry state and the solids disposed of in subsurface storage areas.

Conversion

2.24 The product of a uranium mill is not directly usable as a fuel for a nuclear reactor. Additional processing, generally referred to as enrichment, is required for most types of reactors. This process requires uranium to be in gaseous form and this is achieved by converting the UOC into uranium hexafluoride (UF_6), which is a gas at relatively low temperatures.

2.25 At a conversion facility, uranium is first refined to uranium dioxide (UO_2), which can be used as the fuel for those types of reactors that do not require enriched uranium. Most uranium is then converted into UF_6, ready for the enrichment plant.

Enrichment

2.26 As noted above, natural uranium consists, primarily, of a mixture of two isotopes of uranium. Only 0.71 per cent of natural uranium is fissile, or capable of undergoing fission. The fissile isotope of uranium is uranium-235 (U-235), while most of the remainder is uranium-238 (U-238).

2.27 In the most common types of nuclear reactors, a higher than natural concentration of U-235 is required. The enrichment process produces this higher concentration, typically between 3.5 per cent and five per cent U-235, by removing over 85 per cent of the U-238. This is done by separating UF_6 into two streams, one being enriched to the required level and known as low-enriched uranium. The other is depleted in U-235 and is called 'tails.'

2.28 There are two enrichment processes in large scale commercial use, each of which uses UF_6 as a feedstock—gaseous diffusion and gas centrifuge. Both processes use the physical properties of molecules, specifically the one per cent mass difference, to separate the isotopes. The product of this stage of the nuclear fuel cycle is enriched uranium hexafluoride, which is reconverted to produce enriched UO_2.

Fuel fabrication

2.29 Reactor fuel is generally in the form of ceramic pellets. These are formed from pressed UO_2 which is sintered (baked) at a high temperature (over 1 400 degrees celsius). The pellets are then encased in metal tubes to form fuel rods, which are arranged into a fuel assembly ready for introduction into a reactor. The dimensions of the fuel pellets and other components of the fuel assembly are precisely controlled to ensure consistency in the characteristics of fuel bundles.

Power generation

2.30 Inside a nuclear reactor the nuclei of U-235 atoms split (fission) and, in the process, release energy. This energy is used to heat water and turn it into steam. The steam is used to drive a turbine connected to a generator which produces electricity. Some of the U-238 in the fuel is turned into plutonium in the reactor core (plutonium-239, Pu-239, is formed when the U-238 isotope absorbs a neutron), and this yields about one third of the energy in a typical nuclear reactor. The fissioning of uranium is used as a source of heat in a nuclear power station in the same way that the burning of coal, gas or oil is used as a source of heat in a fossil fuel power plant.

2.31 With time, the concentration of fission fragments (such as bromine, caesium and iodine among others, which are produced from the splitting of the U-235 atoms) and heavy elements, formed in the same way as plutonium in a fuel bundle, will increase to the point where it is no longer practical to continue to use the fuel.[13] After 18–24 months the ‘spent fuel’ is removed from the reactor. The amount of energy that is produced from a fuel bundle varies with the type of reactor and the policy of the reactor operator.

2.32 In a typical light water reactor (LWR), which is the most common type of reactor, fuel elements are used over 3–4 operating cycles, each of 12–18 months (i.e. the reactor might be unloaded every 12 months, with a third of the core being replaced each time).[14]

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13 Fission fragments (or ‘products’) are daughter nuclei resulting either from the fission of heavy elements such as uranium, or the radioactive decay of those primary daughters. Important fission product isotopes (in terms of their relative abundance and high radioactivity) are bromine, caesium, iodine, krypton, rubidium, strontium and xenon. They and their decay products form a significant component of nuclear waste.

14 Australian Safeguards and Non-Proliferation Office (ASNO), *Annual Report 2003–2004*, Commonwealth of Australia, Canberra, 2004, p. 105.

Used fuel storage

2.33 When removed from a reactor, a fuel bundle will be emitting both radiation, principally from the fission fragments, and heat.[15] Used fuel is unloaded into a storage pond immediately adjacent to the reactor to allow the radiation levels to decrease. In the ponds the water shields the radiation and absorbs the heat. Used fuel is held in such pools for several months to several years. Issues associated with waste management are addressed in chapter five and issues associated with radiation and health are addressed further in chapter six.

2.34 Depending on policies in particular countries, some used fuel may be transferred to central storage facilities. Ultimately, used fuel must either be reprocessed or prepared for permanent disposal.

Reprocessing

2.35 In a reprocessing facility the used fuel is separated into its three components: uranium, plutonium and waste (which contains fission products). Reprocessing enables recycling of the uranium and plutonium into fresh fuel, and produces a significantly reduced amount of waste (compared with treating all spent fuel as waste).

2.36 Used fuel is about 95 per cent U-238 but it also contains about one per cent U-235 that has not fissioned, about one per cent plutonium and three per cent fission products, which are highly radioactive, with other transuranic elements formed in the reactor.[16]

Uranium and plutonium recycling

2.37 The uranium from reprocessing, which typically contains a slightly higher concentration of U-235 than occurs in nature, can be reused as fuel after conversion and enrichment, if necessary. The plutonium can be directly made into mixed oxide (MOX) fuel, in which uranium and plutonium oxides are combined. In reactors that use MOX fuel, Pu-239 substitutes for the U-235 in normal uranium oxide fuel.

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15 Radiation may be defined as energy travelling through space, which can be transmitted in the form of electromagnetic waves, or it can be carried by energetic sub-atomic particles. Light and heat from the sun are examples of natural forms of radiation. Radioactivity refers to the spontaneous decay of an unstable atomic nucleus, giving rise to the emission of radiation. See: UIC, *Radiation and the Nuclear Fuel Cycle*, UIC, Melbourne, 2004, viewed 20 June 2005, <www.uic.com.au/nip17.htm>.

16 Transuranics are very heavy elements formed artificially by neutron capture and possibly subsequent beta decay(s). Transuranics have a higher atomic number than uranium (92) and all are radioactive. The best known are neptunium, plutonium, americium and curium.

Used fuel disposal

2.38 The longer that used fuel is stored, the easier it is to manage final disposal, due to the progressive diminution of radioactivity. After 40 to 50 years of storage, the radioactivity level of the fuel falls to 0.1 per cent of its original level. This, and the fact that the volumes of waste involved are not, relatively, large, have meant that final disposal facilities (as opposed to storage facilities) have not been operated since civil nuclear power programs were introduced. There is also a reluctance to dispose of used fuel because it represents a significant energy resource which could be reprocessed at a later date to allow recycling of the uranium and plutonium.

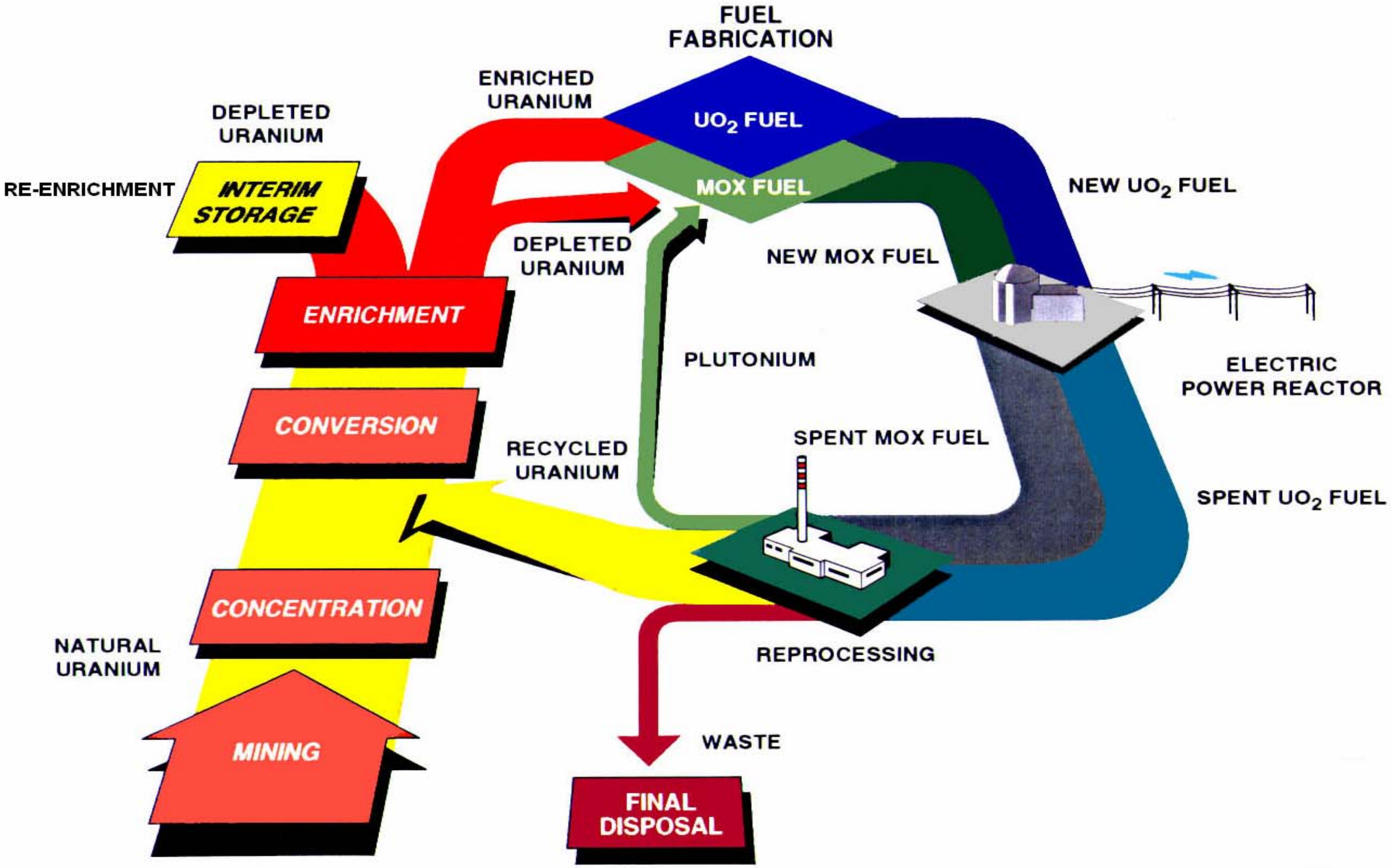
2.39 Technical issues related to disposal have been addressed and a number of countries have determined their own optimum approach to the disposal of used fuel and waste from reprocessing. The most commonly favoured method for disposal is placement into deep geological repositories. The USA is now building a national repository under Yucca Mountain in Nevada, which is scheduled to be operational by 2017. Sweden is proposing to have a deep geological repository in operation by about 2017 and Finland by 2020. Issues associated with the management of the waste produced across the nuclear fuel cycle are addressed in chapter five.

The military fuel cycle

2.40 According to the Australian Safeguards and Non-Proliferation Office (ASNO), the military fuel cycle involves the production of special grades of nuclear material, substantially different to the material used in civil programs, principally plutonium and weapons-grade uranium. While nuclear reactors require uranium enrichment to no more than five per cent, nuclear weapons must have U-235 enriched to about 90 per cent. Weapons-grade plutonium is generally produced in dedicated plutonium production reactors, usually natural uranium fuelled, where irradiated fuel can be removed after short irradiation times. Issues associated with the proliferation of technologies and materials that have military uses, notably uranium enrichment and used fuel reprocessing or plutonium-separation, are addressed in chapter seven.[17]

17 ASNO, *Annual Report 2003–2004, op. cit.*, p. 107.

Figure 2.1 The nuclear fuel cycle



Source Areva

World electricity production

2.41 As the main civil use for uranium is in generating power, the demand for uranium needs to be assessed in the context of world electricity consumption trends and nuclear power's share of electricity production.

2.42 Global primary energy demand is forecast by the International Energy Agency (IEA) to expand by more than half between 2003 and 2030, reaching 16.5 billion tonnes of oil equivalent by 2030. Energy demand is projected to grow at a rate of 1.6 per cent per year over the period.[18]

2.43 According to the IEA, in 2003 world electricity production was 16 742 terawatt-hours (TWh).[19] As listed in table 2.1, fuel for world electricity production was provided 39.9 per cent by coal, 19.2 per cent by natural gas, 6.9 per cent by oil (for a total of 66 percent from fossil fuels), 16.3 per cent by hydro, 1.2 per cent by combustible renewables (such as biomass), and 0.7 per cent from geothermal, solar and wind combined. Nuclear was the fourth largest fuel source for electricity generation at 15.7 per cent.[20]

Table 2.1 Shares of world electricity production by fuel type in 2003

Fuel type	**World production** (TWh)	**Percentage of world total**
Nuclear	2 635.35	15.7
Coal	6 676.24	39.9
Oil	1 151.73	6.9
Natural gas	3 224.70	19.2
Hydro	2 725.82	16.3
Geothermal	53.74	0.3
Solar and wind	68.51	0.4
Combustible renewables	200.70	1.2
Total	**16 741.88**	100

Source IEA, *Electricity Information 2005*, p. I.39.

2.44 Among the fuel types for electricity generation in OECD countries, the strongest growth in the 30 years to 2004 was from solar and wind generation at 17.6 per cent. Aside from renewables, nuclear power experienced the strongest growth, with an average annual growth of

18 IEA, *World Energy Outlook 2005*, OECD/IEA, Paris, 2005, p. 80.

19 One terawatt-hour equals one billion kilowatt-hours of electricity.

20 IEA, *Electricity Information 2005*, OECD/IEA, Paris, 2005, pp. I.39.

electricity generation of 7.8 per cent—larger than the inputs from natural gas (4.2 per cent), coal (2.9 per cent) and hydro (0.8 per cent).[21]

2.45 Electricity generation, which uses some 40 per cent of the world's primary energy supply, is forecast by the IEA to grow at an annual rate of 2.5 per cent between 2002–30, faster than overall energy demand, and rise to 31 657 TWh by 2030. World consumption of electricity is expected to double by 2030.[22]

2.46 Some 1.6 billion people worldwide currently have no access to electricity and demand from developing countries is forecast to more than triple by 2030. In particular, the growth in world demand for electricity is likely to be driven by the industrial modernisation of India and China, with a quarter of the world's projected increase in electricity production to 2030 expected to occur in China. In contrast, growth in electricity demand in the OECD nations will be slower at 1.4 per cent per year.[23]

2.47 According to the IEA, new power plants with a combined capacity of 4 800 gigawatts (GW) are expected to be built worldwide over the period to 2030, with half of these new plants to be built in developing countries. China is expected to require the largest increase, with 860 GW of capacity expected to be added over the period. The IEA estimates that the capacity additions will require investment of over US$4 trillion in new plant construction. Total investment in the electricity sector over the three decades to 2030, including generation, transmission and distribution, is expected to be some $10 trillion.[24]

Nuclear power in the world's electricity generation mix

2.48 Nuclear power programs, which were launched in the USA in the 1960s and in Europe at the beginning of the 1970s, expanded rapidly in the following two decades. Nuclear power generation rose from 100 TWh in 1970 to 2 000 TWh in 1990, with a total of 399 reactors constructed over the period.[25] The rate of growth slowed in the years following, largely as a reaction to public concern about the safety of nuclear reactors after

21 *ibid.*, p. I.22. See also: Cameco Corporation, *Submission no. 43*, p. 7.

22 IEA, *World Energy Outlook 2004*, OECD/IEA, Paris, 2004, pp. 192–193; Nova Energy Ltd, *Submission no. 50*, p. 3; Heathgate Resources Pty Ltd, *Exhibit no. 57, Energy for the World – Why uranium?*, p. 2.

23 IEA, *World Energy Outlook 2004*, *op. cit.*, pp. 193, 196–197. See also: Dr Michael Goldsworthy (Silex Systems Ltd), *Transcript of Evidence*, 9 February 2006, p. 2; Mr James Brough (Australian Nuclear Forum), *Transcript of Evidence*, 16 September 2005, p. 42.

24 IEA, *World Energy Outlook 2004*, *op. cit.*, p. 208.

25 Australian Bureau of Agricultural and Resource Economics (ABARE), *Submission no. 14*, p. 4; Areva, *Submission no. 39*, p. 4.

accidents at Three Mile Island in 1979, Chernobyl in 1986, and Tokaimura in 1999.[26]

2.49 Information published by the World Nuclear Association (WNA) indicates that there are currently 441 commercial nuclear power reactors operating in 31 countries, with an aggregate installed generating capacity of over 369 gigawatts electrical (GWe).[27] In 2005, nuclear reactors produced 2 626 TWh of electricity which, as noted above, represents approximately 16 per cent of world electricity production.[28] Of the 441 nuclear reactors worldwide, 360 are operated by countries eligible to use Australian uranium under bilateral agreements with Australia, described in chapter eight.[29]

2.50 Uranium requirements to fuel the world's reactors are currently 65 478 tonnes of uranium (tU), or 77 218 t U_3O_8, per year.[30] In 2004, world uranium requirements were accounted for principally by the following regions: North America, which used 20 025 tU (38.6 per cent of the world total); Western Europe, which used 17 775 tU (26.4 per cent); East Asia, which used 12 430 tU (18.4 per cent); and Central and Eastern Europe, which used 9 935 tU (14.7 per cent).[31]

2.51 The share of nuclear power in total electricity generation varies significantly across countries, with some 85 per cent of nuclear electricity produced in 17 OECD countries. Nuclear plants account for more than 22 per cent of electricity production in OECD countries (with 61 per cent from fossil fuel plants), while in non-OECD countries only 6.1 per cent of electricity is generated by nuclear plants (with 72.4 per cent from fossil fuels).[32] Western Europe (33.8 per cent), North America (30.6 per cent) and East Asian countries (19.5 per cent) had the largest shares of world installed nuclear capacity in 2004.[33]

2.52 In many countries nuclear power supplies a substantial proportion of national electricity requirements. Some 15 countries generate more than 25 per cent of their total electricity requirements from nuclear power plants (NPPs). Among these, France generates 79 per cent, Lithuania 70 per cent, Belgium 56 per cent, Sweden 47 per cent, South Korea 45 per cent, and

26 *ibid*.

27 Installed capacity is the measure of a power station's electric generating capacity at full production, usually measured in megawatts (MW) or gigawatts (GW).

28 2 626 TWh is 2 626 billion kilowatt-hours.

29 The Hon Alexander Downer MP, *Submission no. 33*, p. 4.

30 WNA, *World Nuclear Power Reactors 2004-06 and Uranium Requirements*, WNA, London, 2006, viewed 10 May 2006, <http://www.world-nuclear.org/info/reactors.htm>.

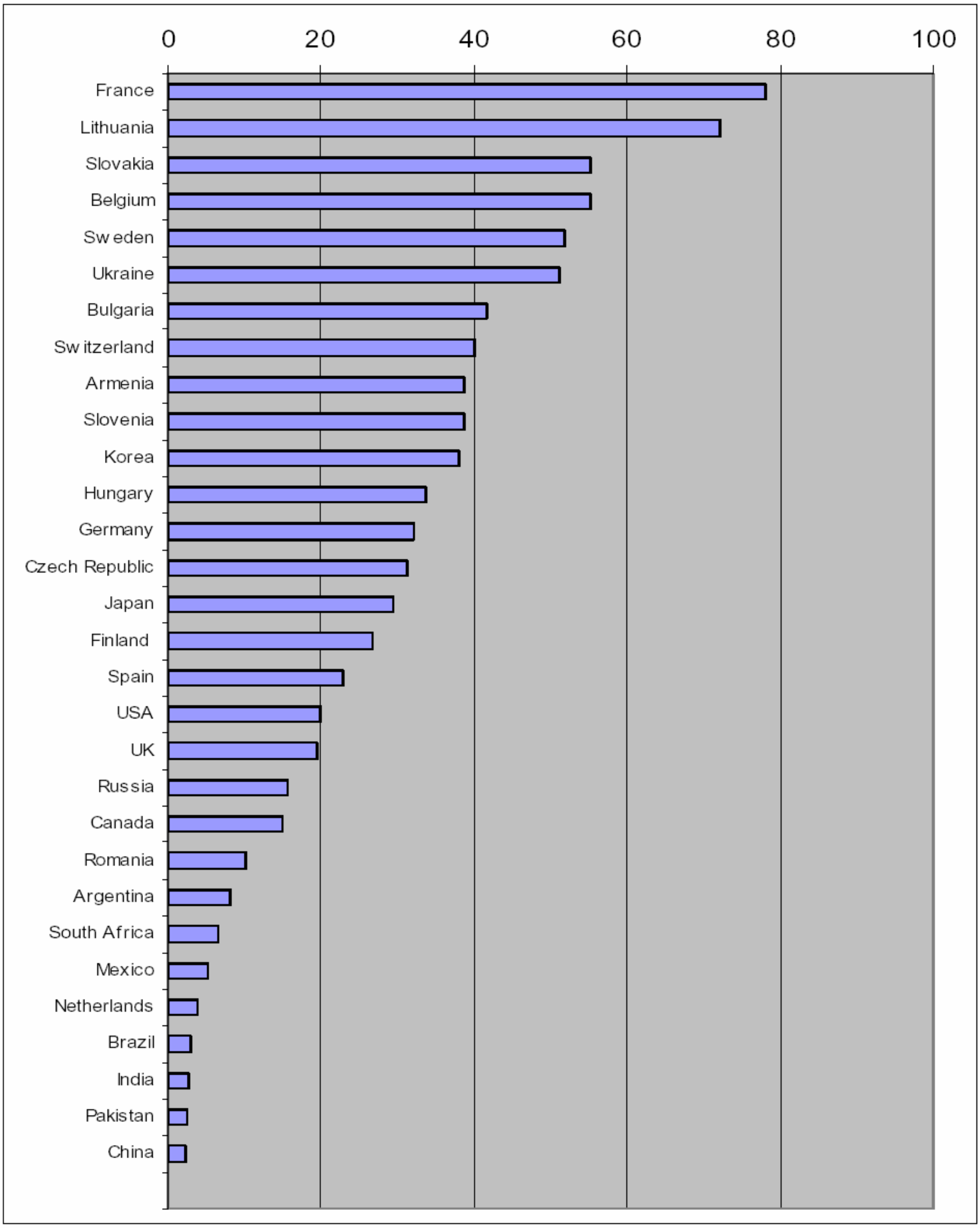
31 IAEA and OECD-NEA, *Uranium 2005: Resources, Production and Demand*, OECD, Paris, 2005, p. 43.

32 IEA, *World Energy Outlook 2004*, *op. cit.*, p. 200; IEA, *Electricity Information 2005*, *op. cit.*, p. I.3.

33 IAEA and OECD-NEA, *loc. cit.*

Japan 29 per cent from NPPs. The USA generates 19 per cent and the UK generates 20 percent from nuclear.[34] The nuclear share of electricity in each country operating NPPs is illustrated in figure 2.2.

Figure 2.2 Nuclear share of electricity by country in 2004, per cent of each country's total



Source WNA, *The Global Nuclear Fuel Market—Supply and Demand 2005–2030*, p. 26.

34 WNA, *World Nuclear Power Reactors 2004-06 and Uranium Requirements*, *loc. cit*; Dr Ron Cameron (ANSTO), *Transcript of Evidence*, 13 October 2005, p. 2.

2.53 The world's nuclear reactors, which are commonly classified according to the type of coolant they use, fall into one of three main categories:

- light water reactors (LWR), which represent over 80 per cent of the nuclear capacity installed in the world. There are 362 LWRs currently in operation and these are divided into two groups: pressurised water reactors (PWR), with 268 in operation in 2005, and boiling water reactors (BWR), with 94 in operation;
- pressurised heavy water reactors (PHWR) designed in Canada, known as 'CANDU' technology, with 40 in operation; and
- gas-cooled Magnox and advanced gas-cooled reactors (AGR), with 23 units operating in the UK.[35]

Other reactor types include fast neutron reactors (four in operation) and Russian-designed graphite-moderated light water reactors, of which there are currently 12 in operation.[36]

2.54 In addition to the world's nuclear reactors used to generate electricity, 56 countries operate a total of 280 research rectors and over 220 small reactors are used for naval propulsion.[37]

The outlook for nuclear power and the demand for uranium

2.55 World demand for uranium, as indicated by the uranium requirements to fuel nuclear reactors, is a function of nuclear electricity generating capacity in operation worldwide, combined with the operating characteristics of individual reactors and the fuel management policies of utilities. Generating capacity is in turn influenced by the outlook for the continued operation of existing NPPs and the prospects for new NPP construction.[38]

2.56 The Committee commences its discussion of these matters by providing an overview of the forecasts for nuclear generating capacity and uranium

35 Areva, *op. cit.*, p. 5. Coolant is a liquid or gas circulating through the reactor core so as to transfer the heat from it. A moderator is material which slows down the neutrons released from fission so that they cause more fission. It is usually water, but may be heavy water or graphite. See: UIC, *Nuclear Power Reactors*, Briefing Paper No. 64, viewed 7 June 2006, <http://www.uic.com.au/nip64.htm>.

36 UIC, *Nuclear Power Reactors*, *loc. cit.*

37 UIC, *Research reactors*, Nuclear Issues Briefing Paper No. 66, UIC, Melbourne, 2004, viewed 10 may 2006, <http://www.uic.com.au/nip66.htm>; UIC, *Nuclear powered ships*, Briefing Paper No. 32, UIC, Melbourne, 2005, viewed 10 may 2006 <http://www.uic.com.au/nip32.htm>.

38 WNA, *The Global Nuclear Fuel Market – Supply and Demand 2005–2030*, WNA, London, 2005, pp. 28, 69, 78; UIC, *Submission no. 12*, p. 29.

demand published by the IEA, WNA, International Atomic Energy Agency (IAEA) and the OECD Nuclear Energy Agency (OECD-NEA).

International Energy Agency

2.57 In terms of forecasts for the world electricity generation mix, the IEA predicts that coal and gas-fired generation will provide over 75 per cent of the world's incremental demand for electricity to 2030. Some 40 per cent of new generating capacity is expected to be gas-fired, while coal-fired capacity is expected to account for some 30 per cent of new construction.[39]

2.58 Coal is forecast to remain the predominant fuel for electricity generation, falling slightly to 38 per cent by 2030. However, while coal's market share in the OECD is expected to decline substantially over the projection period (to 33 per cent in 2030), developing countries are expected to increase their use of coal for electricity generation:

> Over the projection period, most new coal-fired power plants will be built in developing countries, especially in developing Asia. Coal will remain the dominant fuel in power generation in those countries because of their large coal reserves and coal's low production costs. Developing countries are projected to account for almost 60% of world coal-based electricity in 2030. China and India together will account for 44% of worldwide coal-based electricity generation.[40]

2.59 The share of oil in world electricity generation is expected to fall to 4 per cent while natural gas and non-hydro renewables (biomass, wind, geothermal, solar, tidal and wave energy) are predicted to increase their market share. Largely driven by government action in the OECD countries to reduce carbon dioxide emissions, non-hydro renewable sources are forecast to increase from 2 per cent in 2002 to 6 per cent in 2030. Of these, wind power's market share is projected to increase the most, with a tenfold increase from 0.3 per cent of global electricity in 2002. Hydropower's share is forecast to fall to 13 per cent in 2030.[41]

2.60 In both the 2004 and 2005 editions of *World Energy Outlook*, the IEA presents a subdued forecast for nuclear power. The IEA predicts that while nuclear generating capacity will increase in absolute terms, its share of world electricity generation will nearly halve—from 17 per cent in 2004 to 9 per cent in 2030. In its reference scenario, the IEA predicts that world nuclear capacity will increase only slightly to 376 GWe in 2030. While new

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39 IEA, *World Energy Outlook 2004, op. cit.*, pp. 196, 208.

40 *ibid.*, p. 197.

41 *ibid.*, pp. 196–203.

nuclear plants with a combined capacity of 150 GWe are expected to be added by 2030, these will simply replace older reactors being retired in France. The IEA predicts that three quarters of existing nuclear capacity in OECD Europe will be retired by 2030 and over one third of existing plants will be shut down across the entire OECD.[42]

2.61 The IEA notes that three European countries have policies in place to phase out nuclear power (Germany, Belgium and Sweden). The Slovak Republic and the Spanish Government have also canvassed phasing out nuclear power. However, the IEA notes that four OECD countries (France, Finland, Japan and Korea) plan to increase their use of nuclear power.[43]

2.62 While the IEA expects large declines in nuclear production in Europe and an increase in nuclear output in only a few Asian countries, it nonetheless qualifies these predictions by noting that:

> These projections remain very uncertain. Shifts in government policies and public attitudes towards nuclear power could mean that this energy source plays a much more important role than projected here.[44]

2.63 In its *World Energy Outlook* for 2006, the IEA presents a more optimistic forecast for world nuclear generating capacity, concluding that, if public confidence is regained, nuclear power could make a "major contribution" to curbing carbon dioxide emissions, reducing dependence on imported gas and providing baseload electricity supply.[45] In its latest Reference Scenario, the IEA predicts nuclear generating capacity will increase from 368 GW in 2005 to 416 GW in 2030. In its Alternative Policy Scenario, more favourable nuclear policies raise nuclear generating capacity to 519 GW by 2030, so nuclear's share in the world energy mix rises. The IEA also notes that interest in building nuclear reactors has increased as a result of rising fossil fuel prices, which have made nuclear power relatively more competitive. It is concluded that new nuclear plants could produce electricity at less than five US cents per kWh.

2.64 In line with forecasts of increased nuclear generation of electricity, the IEA predicts annual demand for uranium will increase from 68 000 tonnes in 2005 to between 80 000 and 100 000 tonnes by 2030. This demand is expected to be met mainly by new mine production.[46]

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42 *ibid.*, pp. 200, 207.

43 *ibid.*, p. 201.

44 IEA, *World Energy Outlook 2005*, *op. cit.*, p. 85.

45 IEA, *World Energy Outlook 2006*, OECD/IEA, Paris, 2006, p. 43.

46 *ibid.*, p. 376.

World Nuclear Association

2.65 In its 2005 analysis of *The Global Nuclear Fuel Market*, the WNA develops three scenarios for nuclear power to 2030 (lower, reference and upper scenarios), ranging from a slow decline in nuclear generating capacity to a substantial revival over the period.[47]

2.66 In the reference scenario, the WNA assumes continued improvements in the relative economics of nuclear power generation against coal and gas alternatives, public acceptance problems for nuclear begin to diminish, but the concerns about global warming fail to translate into a major shift in the electricity generation mix. In the reference scenario, the WNA predicts that nuclear generating capacity will rise to 378 GWe by 2010 and then grow to 446 GWe by 2020 and to 524 GWe by 2030. This represents an annual average growth rate in nuclear generating capacity of 1.4 per cent over the period. Given that world electricity demand growth is forecast, as noted above, to be substantially greater than this at 2.5 per cent, the WNA accepts that the nuclear share of total generation is likely to decrease substantially to around 13 per cent of the world total in 2030.[48]

2.67 In contrast to the IEA's virtually static outlook for nuclear generating capacity, the WNA's reference case predicts nuclear capacity will rise by 157 GWe in the period to 2030. The WNA argues that:

> The IEA assessment of nuclear shutdown capacity of 150 GW by 2030 looks very high, given recent experience. Although smaller and older reactors will shut down in many countries and politically-inspired closures may take place in others, the current stock of reactors is generally performing very well in economic terms and operating lives are being extended … Other features to note include the extent of actual and planned capacity increases and the widespread development of life extension programs for existing reactors as they are refurbished (Belgium, France, Netherlands, Spain, Sweden, USA).[49]

2.68 The IEA's reactor retirement schedule is also said to assume that nuclear's economic position and public acceptance deteriorates, so existing reactors are retired earlier.[50]

2.69 In the WNA's upper scenario, world nuclear capacity is forecast to be 740 GWe in 2030, which would maintain nuclear's share of world electricity at the current levels of 16–17 per cent. In the lower scenario, nuclear

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47 WNA, *The Global Nuclear Fuel Market – Supply and Demand 2005–2030, op. cit.*, pp. 38–40.

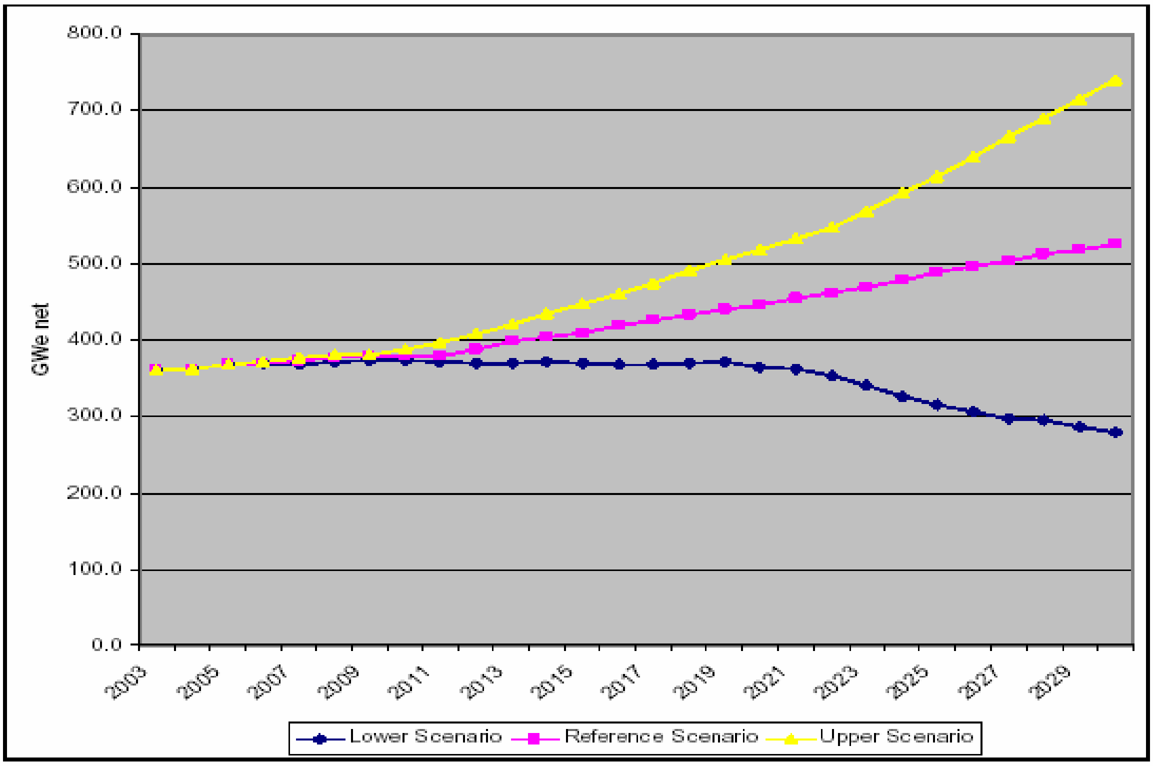
48 *ibid.*, p. 2.

49 WNA, *The New Economics of Nuclear Power*, WNA, London, 2005, p. 14.

50 *ibid.*

generating capacity still rises slightly to 372 GWe by 2010, but then falls away to 279 GWe in 2030.[51] Figure 2.3 illustrates world nuclear generating capacity to 2030 in the three WNA scenarios.

Figure 2.3 World nuclear generating capacity to 2030



Source WNA, *The Global Nuclear Fuel Market—Supply and Demand 2005–2030*, p. 64

2.70 Based on its scenarios for nuclear generating capacity, the WNA has developed demand forecasts for uranium, which take into account a range of factors including the life of existing reactors and prospects for construction of new NPPs. In the reference scenario, reactor uranium requirements are expected to rise from 66 000 tU in 2004 to 71 500 tU in 2010, 84 700 tU in 2020 and to 110 800 tU in 2030, with an annual growth rate of 2 per cent over the period.[52] The prospects for new plant construction are discussed further in the section commencing on page 36.

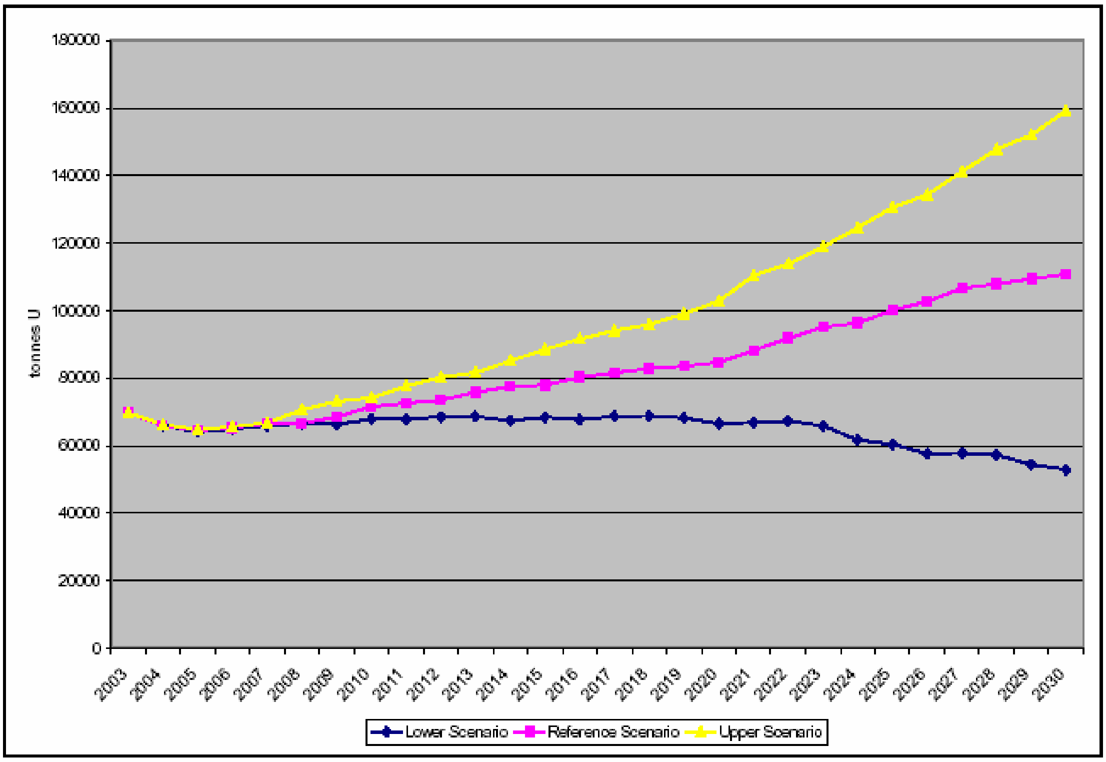
2.71 In the upper scenario, uranium requirements are forecast to be 159 200 tU in 2030, while in the lower scenario they are 52 800 tU in 2030.[53] Figure 2.4 depicts the WNA's forecasts for uranium requirements in the three scenarios to 2030.

51 WNA, *The Global Nuclear Fuel Market – Supply and Demand 2005–2030*, *op. cit.*, p. 2.

52 *ibid.*

53 *ibid.*

Figure 2.4 Uranium requirements to fuel nuclear reactors to 2030



Source WNA, *The Global Nuclear Fuel Market—Supply and Demand 2005–2030*, p.82.

International Atomic Energy Agency and OECD Nuclear Energy Agency

2.72 In the joint IAEA and OECD-NEA publication *Uranium 2005: Resources, Production and Demand,* which is widely cited as an authoritative study and commonly referred to as the 'Red Book', the agencies provide 'low' and 'high' estimates for future nuclear power deployment to 2025.

2.73 The low projection assumes that the present barriers to nuclear deployment continue to prevail in most countries, including low electricity demand growth, continued public opposition to nuclear power and inadequate mechanisms for nuclear technology transfer and project funding in developing countries. The low projection assumes no new nuclear power plants are built beyond what is currently under construction or firmly planned, and old NPPs are retired on schedule.[54] Similar to the IEA reference scenario described above, the agencies' low

54 IAEA and OECD-NEA, *Uranium 2005: Resources, Production and Demand*, *op. cit.*, pp. 53–55; and see also IAEA, *Energy, Electricity and Nuclear Power Estimates for the Period up to 2030*, IAEA, Vienna, July 2005, pp. 6–7, viewed 5 June 2006, <http://www-pub.iaea.org/MTCD/publications/PDF/RDS1-25_web.pdf>.

projection assumes expansion for nuclear power in East and South Asia, contraction in Western Europe and stability in North America.[55]

2.74 In contrast, the high projection assumes a moderate revival of nuclear deployment taking into account global concerns over climate change and implementation of some policy measure to facilitate deployment such as enhancing technology transfer to developing countries.[56]

2.75 The agencies forecast that by 2025 world nuclear capacity will grow to 449 GWe in the low demand case and 533 GWe in the high demand case. The low case represents growth of 22 per cent and the high case represents an increase of 44 per cent from current capacity. Accordingly, uranium requirements are projected to rise to between 82 275 tU and 100 760 tU by 2025, representing 22 per cent and 50 per cent increases respectively, compared to the 2004 total.[57]

2.76 The Red Book qualifies its projections for nuclear capacity and uranium demand, noting that there are 'great uncertainties in these projections as there is an ongoing debate on the role that nuclear energy will play in meeting future energy requirements.'[58]

2.77 In general, the IAEA notes 'a sense of rising expectations for nuclear power' and states that its current projections are markedly different from even four years ago.[59] The IAEA explains that its revised forecasts have been driven by:

> … nuclear power's performance record, by growing energy needs around the world coupled with rising oil and natural gas prices, by new environmental constraints including entry-into-force of the Kyoto Protocol, by concerns about energy supply security in a number of countries, and by ambitious expansion plans in several key countries.[60]

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55 IAEA, *Nuclear Technology Review – Update 2005*, IAEA, Vienna, July 2005, p. 8, viewed, 5 June 2006, <http://www.iaea.org/About/Policy/GC/GC49/Documents/gc49inf-3.pdf>.

56 IAEA, *Energy, Electricity and Nuclear Power Estimates for the Period up to 2030, loc. cit.*

57 IAEA and OECD-NEA, *Uranium 2005: Resources, Production and Demand*, *op. cit.*, pp. 10, 53.

58 *ibid.*, p. 11.

59 Dr Mohamed ElBaradei, *Nuclear Power: Preparing for the future*, Statements of the Director General of the IAEA, 21 March 2005, viewed 5 June 2006, <http://www.iaea.org/NewsCenter/Statements/2005/ebsp2005n004.html>.

60 IAEA, *Nuclear Technology Review – Update 2005*, *op. cit.*, p. 1.

The prospects for nuclear power and new plant construction

2.78 Evidence to the Committee was sharply divided on the prospects for future nuclear capacity and particularly on the outlook for new NPP construction.

2.79 The IAEA and OECD-NEA state that the key factors that will influence future nuclear electricity capacity and construction include:

- projected growth of base load electricity demand;
- the cost-competitiveness of new NPPs and fuel compared to other energy sources, particularly with deregulation of electricity markets;
- concerns about security of fuel supplies;
- public attitudes and acceptance towards the safety of nuclear energy and proposed waste management strategies;
- concerns about the connection between the civil nuclear fuel cycle and military uses; and
- environmental considerations, in particular consideration of the role nuclear energy can play in reducing air pollution and greenhouse gas emissions.[61]

2.80 For the IAEA and OECD-NEA, 'evidence suggests that many nations have decided that the balance of these factors supports construction of new nuclear power plants', with significant building programs now underway in China, India, Japan and the Russian Federation.[62]

2.81 The installation of new nuclear capacity will increase uranium requirements where new construction outweighs reactors retirements. According to information published by the WNA, at the end of May 2006 there were 27 nuclear reactors under construction in 11 countries (which will have a generating capacity of 21 GWe), with a further 38 planned or on order (40.7 GWe) and another 115 reactors are proposed (65.4 GWe).[63] During 2003 and 2004 seven new reactors commenced to produce electricity, while 11 reactors were permanently shut down (eight in the UK).[64] The world's nuclear power reactors, reactors being constructed, planned and proposed, and their uranium requirements are listed by country in appendix D.

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61 IAEA and OECD-NEA, *Uranium 2005: Resources, Production and Demand*, *op. cit.*, p. 52.

62 *ibid*.

63 WNA, *World Nuclear Power Reactors 2004-06 and Uranium Requirements*, *loc. cit.*

64 IAEA and OECD-NEA, *Uranium 2005: Resources, Production and Demand*, *op. cit.*, p. 42.

2.82 While existing NPPs are clustered in Europe, the US and Japan, submitters observed that new construction is currently centred in the Asian region, notably China, India and South Korea, with 18 plants (or 66 per cent of the total) currently under construction.[65]

2.83 The IAEA notes that 'current expansion, as well as near-term and long-term growth prospects, is centred in Asia', and that 20 of the last 30 reactors to have been connected to the grid were in Asian countries.[66] The WNA also predicts that over the next few years nuclear construction will be concentrated in Asia (China, South Korea and India), and to some extent in Russia and other Eastern European countries.[67]

2.84 China currently has four reactors under construction and is planning a fivefold increase in nuclear capacity from 6.6 GWe to 40 GWe by 2020.[68] The expansion will require the construction of two reactors every year over the period.[69] India is currently constructing eight reactors and intends to triple nuclear generating capacity to 20 GWe by 2020. India also plans that by 2050 nuclear power will contribute 25 per cent of the country's electricity generation—a hundredfold increase on 2002 nuclear generating capacity.[70] Japan currently has one plant under construction and plans to build another 12 reactors. Japan also plans to expand nuclear's contribution to 41 per cent of total electricity generation by 2014, up from 29 per cent currently.[71] Indonesia will commence construction of its first NPP in 2010, to be completed by 2016, with plans for a further three NPPs to be constructed by 2025.[72] Plants are also being considered in Vietnam, Malaysia, Poland, Belarus, Turkey, Serbia and Egypt.[73]

2.85 Elsewhere, the Russian Federation plans to raise nuclear capacity from 22 GWe to 40–45 GWe by 2020, and has four reactors currently under

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65 UIC, *Submission no. 12*, p. 7; Areva, *loc. cit*. This figure also includes two NPPs currently under construction in Taiwan. See also: Minerals Council of Australia, *Submission no. 36*, p. 6; ANSTO, *Submission no. 29*, p. 3.

66 IAEA, *Nuclear Technology Review – Update 2005*, *op. cit.*, p. 4. See also: Dr Ron Cameron, *op. cit.*, pp. 1–2.

67 WNA, *The Global Nuclear Fuel Market – Supply and Demand 2005–2030*, *op. cit.*, p. 33.

68 UIC, *Nuclear Power in China*, Nuclear Issues Briefing Paper No. 68, viewed 6 June 2006, <http://www.uic.com.au/nip68.htm>.

69 Mr Alan Eggers (Summit Resources Ltd), *Transcript of Evidence*, 3 November 2005, p. 1.

70 UIC, *Nuclear Power in India and Pakistan*, Nuclear Issues Briefing Paper No. 45, viewed 1 June 2006, <http://www.uic.com.au/nip45.htm>.

71 WNA, *World Nuclear Power Reactors 2004-06 and Uranium Requirements*, *loc. cit*. UIC, *Nuclear Power in Japan*, Briefing Paper No. 79, viewed 6 June 2006, <http://www.uic.com.au/nip79.htm>.

72 The Hon Alexander Downer MP, *Submission no. 33.2*, pp. 9–10.

73 Dr Ron Cameron, *op. cit.*, p. 2; Cameco Corporation, *Submission no. 43*, pp. 3–4.

construction.[74] Finland has commenced construction on a new plant—the first new nuclear construction in Western Europe since 1991, and France plans to commence construction of a new reactor (the European Pressurised Water Reactor) in 2007.[75]

2.86 Several submitters expressed 'optimism and enthusiasm about the opportunities for nuclear energy', pointing variously to the:

- growing world demand for electricity;
- life extensions and refurbishments of existing reactors;
- increasing concern about greenhouse gas emissions and security of fuel supply; and
- plans for significant new NPP construction in several countries and renewed interest in some industrialised nations.[76]

For Cameco, these favourable trends are expected to result in 470 nuclear reactors being in operation by 2015.[77]

2.87 Compass Resources argued that:

> … driven partly by high fossil fuel costs and the greenhouse gas reduction imperative … it seems likely that nuclear energy will play an increasing role in meeting the growth in world energy demand.[78]

2.88 The MCA cited a number of recent developments it claims indicates that nuclear electricity generation will continue to grow:

- during 2004 seven new reactors were connected to electricity grids overseas and another was restarted after major refurbishment;
- Japan's newest and largest Advanced Boiling Water Reactor has commenced commercial operation bringing the country's number of reactors in commercial operation to 54. In addition, grid connection of the first unit of a further nuclear power plant is expected with

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74 Dr Mohamed ElBaradei, *Nuclear Power: Preparing for the future*, *loc. cit.*

75 *ibid*. See also: IAEA, *Nuclear Technology Review – Update 2005*, *op. cit.*, p. 6; UIC, *Nuclear Power in Russia*, Briefing Paper No. 62, viewed 6 June 2006, <http://www.uic.com.au/nip62.htm>; UIC, *Nuclear Energy in Finland*, Briefing Paper No. 76, viewed 6 June 2006, <http://www.uic.com.au/nip76.htm>; UIC, *French Nuclear Power Program*, Briefing Paper No. 28, viewed 6 June 2006, <http://www.uic.com.au/nip28.htm>.

76 See for example: Cameco Corporation, *op. cit.,* p. 2; Energy Resources of Australia Ltd, *Submission no. 46*, p. 3; ANSTO, *Exhibit no. 74, Presentation by Dr Ian Smith and Dr Ron Cameron*, p. 8; Jindalee Resources Ltd, *Submission no. 31*, p. 2; Summit Resources Ltd, *Submission no. 15*, p. 20.

77 Cameco Corporation, *loc. cit*.

78 Dr Malcolm Humphreys (Compass Resources NL), *Transcript of Evidence*, 16 September 2005, p. 62.

commercial operation in October 2005. At least three more units are expected to be built or are planned to be built at this site;

- the 20th nuclear power reactor in the Republic of Korea (and sixth Korean Standard Nuclear Power Plant) was connected to the grid in December 2004 and a further four plants are due to come on line over the period 2010–2013;
- the Republic of Korea is also establishing a joint venture in Kazakhstan to mine uranium;
- in a speech given by the President of the United States to the April 2005 National Small Business Conference, President Bush said:

> … the first essential step toward greater energy independence is to apply technology to increase domestic production from existing energy resources. And one of the most promising sources of energy [for the USA] is nuclear power;

- public sentiment in Sweden and to an extent in the UK, among others, appears to be changing in favour of nuclear power according to various polls. In Sweden, which has faced the prospect of phasing out nuclear power, public opinion is now 80 per cent favourable. The change reflects public concern and media coverage related to energy security and environmental concerns, particularly regarding climate change;
- various nuclear generators in Europe and the USA are implementing capacity upgrades and extending operating licenses—one third of the current 103 US plants have had 20 year licence extensions; and
- the chief executives of 20 European Union energy companies recently called upon governments to make nuclear power a central part of their energy policies on the basis of energy security and environmental protection.[79]

2.89 Mr Lance Joseph, Australian Governor on the Board of the IAEA from 1997 to 2000, asserted that:

> The civilian nuclear industry is poised for world-wide expansion. Rapidly growing demand for electricity, the uncertainty of natural gas supply and price, soaring prices for oil, concern for air pollution and the immense challenge of lowering greenhouse emissions, are all driving a fresh look at nuclear power. At the same time, fading memories of Three Mile Island and Chernobyl is increasing confidence in the safety of new reactor designs. So the

79 MCA, *Submission no. 36*, p. 8. The Medical Association for the Prevention of War (MAPW) (WA Branch) note similar favourable demand side trends in *Submission no. 8*, p. 4.

> prospect, after a long hiatus, of new nuclear power construction is real, with new interest stirring in countries throughout the world.[80]

2.90 Similarly, the Australian Nuclear Forum (ANF) proposed that use of nuclear power will expand and demand for reactor fuel will increase as:

> … the fear of more 'Chernobyl's' recedes and it becomes clearer that fossil fuel plants cannot be made sufficiently environmentally friendly and that the 'alternative' methods of generating electricity prove to be incapable of meeting demand.[81]

2.91 ANSTO argued that given the expansion plans announced by several countries and nuclear's improved economic competitiveness due to fuel cost increases and emission constraints impacting upon fossil fuels:

> It seems clear … that the proportion of the world's electricity that is derived from nuclear power will increase from present levels during the next two or three decades, and the demand for uranium will increase correspondingly.[82]

2.92 The UIC cited forecasts prepared by International Nuclear Inc (iNi), an independent consulting organisation which specialises in uranium supply-demand-price trends, which broadly supports the WNA's conclusions summarised above. iNi forecasts that uranium oxide requirements will rise to nearly 84 000 tonnes per year by 2010 and to almost 91 900 tonnes by 2020. These forecasts are said to be conservative in that they make no allowance for a potential increase in nuclear generation arising from concerns over greenhouse gas emissions from other forms of electricity generation.[83]

2.93 ANSTO also noted that, to date, plans for new nuclear build have been driven primarily by energy demand and not by greenhouse gas mitigation concerns.[84] The Department of the Environment and Heritage (DEH) also noted that, in addition to the 'massive growth in energy demand' in India and China, countries expanding the use of nuclear power are doing so for reasons of energy security.[85]

2.94 Energy Resources of Australia Ltd (ERA) also emphasised the role of energy security, arguing that 'market behaviour has fundamentally changed, with security and stability of fuel supply becoming the most

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80 Mr Lance Joseph, *Submission no. 71*, p. 1.
81 ANF, *Submission no. 11*, p. 2.
82 ANSTO, *op. cit.*, pp. 3–4.
83 UIC, *Submission no. 12*, p. 8.
84 Dr Ron Cameron, *loc. cit*.
85 Mr Barry Sterland (DEH), *Transcript of Evidence*, 10 October 2005, p. 14.

important issues for nuclear utilities.'[86] ERA noted that utilities are increasing plant output and operating efficiencies, which are in turn increasing uranium demand. Power plant construction is also being seen as an important option in responding to greenhouse gas emissions.[87]

2.95 ERA also pointed to new NPP construction around the world. It was argued that while no new orders have yet been placed in North America, significant pre-order work is being undertaken by utilities, including applications for early site permits and the streamlining of regulatory processes. In addition, countries such as Chile, which were previously opposed to nuclear power, are now considering the nuclear option.[88]

2.96 In 2002 the US Government launched Nuclear Power 2010 (NP 2010), a public-private partnership to identify new sites for plants, develop advanced reactor technologies and test new regulatory processes. NP 2010 assumes that the first new power plant order will be placed in 2009 and construction will be completed by 2014. Ten energy companies or consortia in the US have indicated that they will apply to build 16 new NPPs.[89]

2.97 In contrast to these assessments, groups critical of nuclear power argued that construction of new reactors is unlikely to keep pace with retirements. The Australian Conservation Foundation (ACF) argued that there is likely to be no significant expansion of global nuclear power or total uranium demand. ACF predicted that the number of nuclear power plants across the western world will decline over the next 25 years:

> The number of reactors across the USA and western Europe peaked some 15 years ago and is highly likely to continue to decline with the scheduled closure of some 50 nuclear power plants in western Europe across a range of countries, given government legislation, government policy and government schedules of closure based on ageing and unsuitability for extension of life for existing reactors.[90]

2.98 Specifically, the ACF argued that:

- across the EU-15 countries in the last 25 years only two NPPs have been ordered and started construction (France in 1991 and Finland in 2004);

86 ERA, *Submission no. 46*, p. 2.

87 *ibid.*, p. 3.

88 *ibid.*, pp. 2-3. See also: MAPW (WA Branch), *op. cit.*, p. 3.

89 ABARE, *loc. cit*; Dr Ron Cameron, *op. cit.*, p. 10.

90 Mr David Noonan (ACF), *Transcript of Evidence*, 19 August 2005, p. 75.

- in the expanded EU-25 group of countries, Finland has the only new plant under construction and there is one other at a planning stage, in France;
- the number of reactors in the EU-25 will continue to decline with legislative nuclear power phase outs in Germany and Belgium, to see 25 NPPs close by 2025;
- nuclear phase out policies exist in Spain, the Netherlands and Sweden, which will see a further 21 NPPs close by 2030;
- in the UK, nine NPPs are set to close from 2007 to 2020 due to the ageing of plants that are unsuited to life extensions; and
- in the USA, despite Presidential support for nuclear power, there has not yet been an order for a new reactor.[91]

2.99 It was argued that the only prospects for significant expansion of nuclear power are in India and China. ACF noted that in China the nuclear share of electricity generation will 'only increase from the present 2% toward some 6–10% by 2025'.[92] While it was conceded that this represents a significant increase in nuclear generating capacity, it was argued that this 'shows that nuclear is not a major answer to electricity supply in China in the foreseeable future'.[93]

2.100 Friends of the Earth (FOE) also stated that the future of nuclear power is uncertain. It was argued that, assuming a reactor life of 40 years, a total of 280 reactors will need to be built over the next 20 years to offset reactor shutdowns. FOE claimed that 'even if lifetime extensions significantly increase the average reactor lifespan, it is doubtful whether new reactors will keep pace with shut downs.'[94]

2.101 Consistent with the IEA view, ABARE also argued that despite a substantial amount of capacity expected to be added in Japan, China, India, the Russian Federation and South Korea, 'total growth in nuclear capacity will be largely offset by reactor retirements, particularly in Europe.'[95] ABARE predicted that world demand for uranium will rise by one per cent over 2005 and 2006.

2.102 More broadly, the Uniting Church (Synod of Victoria and Tasmania) claimed that demand for uranium will fall over time due to: legislative phase outs of nuclear power in some countries; investment in nuclear power being overly risky; 'unresolved' waste storage issues; safety and

91 ACF, *Submission no. 48*, p. 4–5.
92 *ibid.*, p. 5.
93 *ibid.* See also: Mr David Noonan, *op. cit.*, p. 76.
94 FOE, *Submission no. 52*, p. 4. See also: Wind Prospect Pty Ltd, *Submission no. 4*, p. 2.
95 ABARE, *loc. cit.*.

health problems; and security concerns associated with use of nuclear power.[96]

2.103 ACF also noted that the IAEA has predicted that nuclear's share of world electricity supply will drop to 12 per cent in its low forecast by 2030. Cameco agreed that there may be a decline in the proportion of the world's energy supplied by nuclear, given the predicted overall growth in energy demand. However, it was argued that total nuclear capacity will still increase, as was concluded in the forecasts summarised above.[97]

2.104 Mr Ian Hore-Lacy, General Manager of the UIC, observed that there is a renewal of interest in nuclear power in Europe, beyond the new plants announced for Finland and France:

> I do not see any reduction in nuclear capacity or interest in Europe. I note the policies of the German government, I note the policies of the Swedish government and I note that those policies are timed, as it were, to possibly take effect way into the future, several changes of government away. In other words, for Germany it will be about 2010 before their current policies matter, if they last that long. In fact, they might not last till Christmas.[98]

2.105 The UIC argued that it is now well understood that German policies to phase out nuclear power, while simultaneously increasing renewables to 20 per cent of total electricity, will be impossible without also adding significant new capacity from fossil fuel plants. However, this will make the country's carbon dioxide reduction target under the Kyoto Protocol simply unattainable.[99] More generally, Nova Energy argued that in both Germany and the UK there is opposition to nuclear phase outs as renewables cannot provide baseload power requirements. The Committee addresses these matters further in chapter four.

2.106 ABARE noted that, rather than shutting down reactors, some European countries are now reconsidering nuclear energy and others are looking to extend the life of existing reactors by up to 20 years.[100] Claims of renewed public support for nuclear power in Europe were also supported by a range of opinion polls conducted in countries including Sweden, Germany and the Netherlands.[101]

2.107 In general, BHP Billiton expressed confidence that:

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96 The Uniting Church in Australia (Synod of Victoria and Tasmania), *Submission no. 40*, pp. 9–13.

97 Mr Jerry Grandey (Cameco), *Transcript of Evidence*, 11 August 2005, p. 15.

98 Mr Ian Hore-Lacy (UIC), *Transcript of Evidence*, 19 August 2005, p. 90.

99 UIC, Exhibit no. 49, Nuclear Industry in Europe, p. 3; Nova Energy Ltd, *op. cit.*, p. 4.

100 Mr Will Mollard (ABARE), *Transcript of Evidence*, 5 September, p. 14.

101 Mr John Reynolds, *Submission no. 5*, p. 8.

> … all credible projections of world energy demand and supply options indicate that uranium does have an important role to play in meeting the world's energy needs. We believe … that the meeting of these needs will require a mix of fuels, fossil fuels, uranium and renewable energy sources.[102]

2.108 Specifically, BHP Billiton estimated that, as a proportion of all energy sources, nuclear power will increase. As a consequence, the company predicts a 60 per cent increase in demand for uranium over the next decade.[103]

Existing plant performance and uranium demand

2.109 As mentioned above, in addition to installed nuclear capacity and the outlook for new plant construction, the demand for uranium is also influenced by the performance and operating characteristics of reactors, and fuel management policies of utilities. Among these is the capacity factor (or 'load factor') of reactors, which is the actual power generated during a period of time expressed as a percentage of the power which would have been generated if the plant had operated at full power continuously throughout the period. The WNA explains that a rise in load factor is a main influence on demand for uranium (and enrichment), with a nearly linear relationship between load factor and fuel requirements.[104]

2.110 In addition to the prospects for new nuclear build, the UIC, ANSTO, Paladin Resources and Areva emphasised the substantial increases in nuclear generating capacity that have been achieved in recent years due to gains in existing NPP availability and productivity. Areva stated that while installed nuclear capacity increased by only 1.2 per cent over the period 1989 to 2004, following the Chernobyl accident, nuclear power generation continued to grow at an average annual rate of 2.1 per cent over the period due to efficiency improvements at existing reactors. Thus, the average reactor capacity factor rose from 67 per cent in 1989 to over 80 per cent by the end of 2004.[105]

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102 Dr Roger Higgins (BHP Billiton Ltd), *Transcript of Evidence*, 2 November 2005, p. 2.

103 *ibid.*, p. 20.

104 WNA, *The Global Nuclear Fuel Market – Supply and Demand 2005–2030*, *op. cit.*, pp. 70–72. Among the other factors are: reactor operation cycle lengths, selection of tails assay (e.g. increased enrichment effort lowers the tails assay, which means less natural uranium is required), the ratio between natural uranium and enrichment prices, fuel design and management, fuel burn up, and reactor power levels. These factors are discussed in: WNA, *The Global Nuclear Fuel Market – Supply and Demand 2005–2030*, op. cit., pp. 69–79; IAEA and OECD-NEA, *Uranium 2005: Resources, Production and Demand*, *op. cit.*, p. 51–52.

105 Areva, *loc. cit.*

2.111 Similarly, Dr Mohamed ElBaradei, Director General of the IAEA, has observed that in 1990 nuclear plants on average were generating electricity 71 per cent of the time, but by 2003 availability had increased to 81 per cent. This represented 'an improvement in productivity equal to adding more than 25 new 1 000 megawatt nuclear plants—all at relatively minimal cost.'[106] Furthermore, Professor Leslie Kemeny noted that by 2005 reactor capacity reached a record average of 91.5 per cent in the USA.[107]

2.112 The UIC noted that the increase in output from existing plants over the past five years has amounted to 235 TWh, which is equal to the output from 33 large new nuclear plants.[108] The increased productivity and availability of NPPs lead to the gains in output mentioned, which in turn leads to an increased demand for uranium.

2.113 A significant increase in output has also been attained through 'up-rating' the capacity (i.e. increasing the power levels) of some plants, by up to 15–20 per cent. According to the WNA this has been a particular focus in the USA, Sweden and Eastern European countries.[109]

2.114 The UIC also noted that a considerable number of reactors are being granted life extensions. For example, in the USA, the Nuclear Regulatory Commission has now approved license extensions for 30 NPPs, adding 20 years to the originally licensed plant life of 40 years. Some 85 NPPs in the USA are eventually expected to be granted licence renewals.[110] The IAEA has reported that approximately three quarters of the USA's 104 NPPs have either received, applied for, or stated their intention to apply for a license extension.[111] Furthermore, ANSTO noted that 60 years is now seen as the minimum operating lifetime for reactors in Japan.[112]

2.115 While reactors are being operated more productively, with higher capacity factors and power levels mentioned above, efficiencies are dampening demand for uranium. For example, increased burn up of nuclear fuel has reduced uranium requirements and increased enrichment requirements. Many utilities are increasing the initial enrichment of their fuel (e.g. from 3.3 per cent to more than 4 per cent U-235) and then burning the fuel longer or harder to leave only 0.5 percent U-235. Over the 20 years from

106 Dr Mohamed ElBaradei, *Nuclear Power: Preparing for the future*, *loc. cit.*

107 Professor Leslie Kemeny, *Exhibit no. 9, Power to the people*, p. 2.

108 UIC, *Submission no. 12*, p. 7. See also: ANSTO, *op. cit.*, p. 4; Dr Mohamed ElBaradei, *Nuclear Power: Preparing for the future*, *loc. cit.*

109 WNA, *The New Economics of Nuclear Power*, *op. cit.*, p. 12. See also; Paladin Resources Ltd, *Submission no. 47*, p. 4.

110 UIC, *Submission no. 12*, p. 7.

111 IAEA, *Nuclear Technology Review – Update 2005*, *op. cit.*, p. 6.

112 ANSTO, *loc. cit.*

1970, there was a 25 per cent reduction in uranium demand per kWh output in Europe.[113]

Supply of uranium

2.116 At the end of 2004 commercial nuclear reactors in operation worldwide required 67 320 tU (or 79 390 t U_3O_8), of which world uranium mine production supplied 40 263 tU, or approximately 60 per cent of requirements.[114] This was an improvement on the previous year, in which world mine production (35 772 tU) provided only 52 per cent of world demand (68 435 tU).[115]

2.117 Coverage of annual uranium requirements by mine production rose to an estimated 64.9 per cent in 2005 due to an increase in production levels to 41 869 tU, coupled with a slight decline in global uranium requirements to 64 600 tU.[116]

2.118 World uranium mine production (also referred to as primary production) is insufficient to meet uranium requirements, meeting an average of only 57 per cent of annual requirements over the past 14 years. The shortfall has been met by secondary sources of supply since the late 1980s. Secondary supplies are essentially inventories, stockpiles and recycled materials of various types. These supplies can be regarded as previous uranium production held off the commercial nuclear fuel market for an extended period.[117]

2.119 Figure 2.5 shows the relationship between world mine production and uranium requirements for electricity generation (including the former Soviet Union and Eastern bloc countries). The continuous line shows world demand for uranium and the dashed line shows mine production. The shaded region between demand and primary production illustrates the balance of supply provided by secondary sources.

113 UIC, *Submission no. 12,* p. 29. See also: WNA, *The Global Nuclear Fuel Market – Supply and Demand 2005–2030*, *op. cit.*, pp. 77–78.

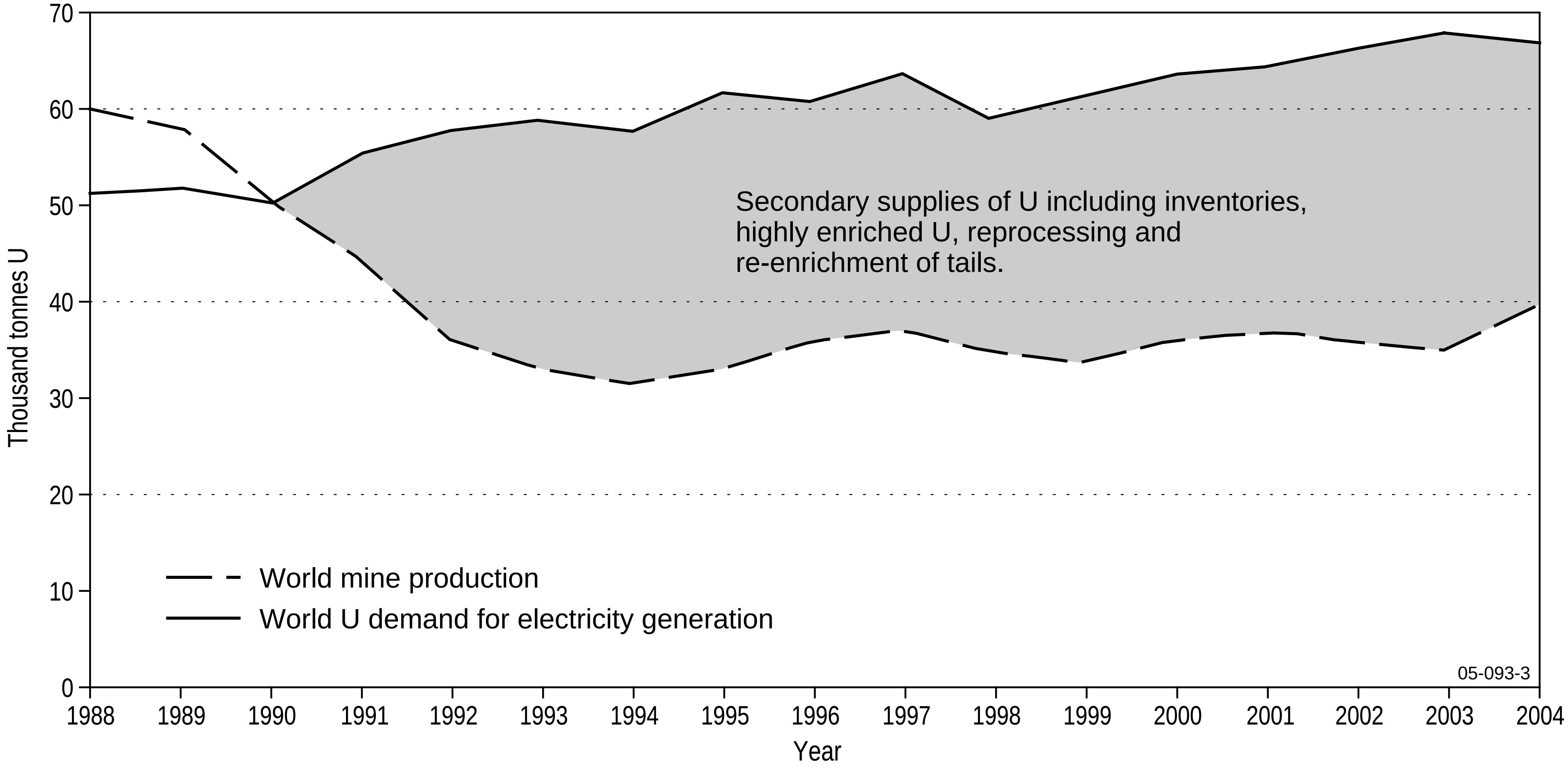
114 IAEA and OECD-NEA, *Uranium 2005: Resources, Production and Demand*, *op. cit.*, p. 10. One tonne of uranium oxide is equivalent to 0.848 tonnes of uranium.

115 Geoscience Australia, *Submission no. 42*, p. 12.

116 RWE NUKEM, *NUKEM Market Report*, May 2006 edition, RWE NUKEM Inc, Danbury, Connecticut, May 2006, p. 22.

117 WNA, *The Global Nuclear Fuel Market – Supply and Demand 2005–2030*, *op. cit.*, pp. 127–128.

Figure 2.5 Comparison of world uranium mine production and world uranium demand for electricity generation, 1988–2004



Source Geoscience Australia, *Submission no. 42*, p. 12.

Secondary sources of supply

2.120 While secondary supply sources are a common feature in commodity markets, Geoscience Australia (GA) noted that 'uranium is unique among energy fuel resources in that a significant portion of demand is supplied from secondary sources rather than mine production.'[118] Fuel requirements in excess of world mine production are currently met from the following secondary sources, in decreasing order of importance:

- stockpiles of natural and low-enriched uranium (LEU), held by electricity utilities and conversion plants—up to 30 per cent of total world demand;
- down-blending of highly enriched uranium (HEU) removed from decommissioned weapons and military stockpiles in both the Russian Federation and the USA—10 to 13 per cent of world demand. Current arrangements run up to 2013, covering the period of Moscow Treaty reductions, described below;
- re-enrichment of depleted uranium tails, which involves recovering the residual fissile material from depleted uranium tails at enrichment plants—3 to 4 per cent of world demand. This is only commercially viable if there are enrichment plants with low operating costs and available excess capacity; and
- uranium from reprocessing used reactor fuel (known as reprocessed uranium or 'RepU')—approximately 1 per cent of world demand.[119]

In addition, some 2–3 per cent of the demand for reactor fuel is met by the use of recycled plutonium in the form of MOX.[120]

2.121 In February 1993 the Russian Federation and US Governments entered into an HEU Purchase Agreement for the disposition of HEU extracted from nuclear weapons (the so-called 'Megatons to Megawatts' program).[121] The Agreement committed Russia to convert (down-blend) 500 tonnes of HEU from its dismantled nuclear warheads into LEU for civilian use. Under the Agreement, the US Enrichment Corporation receives deliveries of LEU from the Russian Federation for sale to

118 GA, *Exhibit no. 61, op. cit.*, p. 10.

119 The Hon Alexander Downer MP, *Submission no. 33*, p. 4; GA, *Submission no. 42*, p. 5.

120 In January 2005 there were 35 reactors (8 per cent of the world's operating fleet) licensed to use MOX fuel.

121 See: *Report on the Effect of the Low-Enriched Uranium Delivered Under the HEU Agreement* published by the US DOE, 2004, viewed 16 June 2005, <http://www.ne.doe.gov/reports/RptEffectLow-Enriched%20UraniumDec312004.pdf>. A paper on *The US-Russia HEU Agreement* has been published by the WNA, viewed 9 June 2006, <http://www.world-nuclear.org/trade_issues/tbriefings/heu/index.htm>.

commercial NPPs. ABARE noted that this quantity of HEU is equivalent to approximately 150 000 tonnes of natural uranium, or twice annual world demand.[122] The HEU Purchase Agreement will run for 20 years until 2013 and is supplying the equivalent of some 9 000 tonnes of natural uranium per year on average.[123]

2.122 Silex observed that the Russian HEU material sold to the US has meant that: 'More than 10 000 Russian nuclear warheads have been converted to electricity through this path.'[124] The MAPW (WA Branch) cited research by the Nuclear Energy Institute which found that former Russian warheads were powering one in ten US homes in 2004.[125] A smaller amount of ex-military uranium from US sources is also beginning to become available.

2.123 While it is anticipated that secondary supplies will continue to play a major role in supplying commercial markets, GA and other submitters observed that there is now considerable uncertainty about the quantities of secondary supplies likely to be available for the market in the future. One source of uncertainty is that many countries are unable to provide detailed information on government (i.e. ex-military) and utility stockpiles due to confidentiality concerns.[126]

2.124 ASNO observed that of the secondary sources of supply listed above, only re-enrichment of depleted uranium tails can be increased to maintain supply in the event of a major drawdown of utility inventories. It is expected that the stockpiles accumulated by utilities in the 1970s and 1980s will be exhausted over the next decade and the supply of HEU retired from weapons will also fall away, unless more is released from weapons stockpiles.[127]

2.125 Submitters commented that the supply of Russian HEU is gradually coming to an end. The Russian Federation is now choosing to retain HEU to meet its own demand for electricity generation, which cannot be met by its own mine production, and hence no follow-on HEU purchase

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122 Mr Will Mollard (ABARE), *Transcript of Evidence*, 5 September 2005, p. 14.

123 Areva, *op. cit.*, p. 9.

124 Dr Michael Goldsworthy (Silex Systems Ltd), *Transcript of Evidence*, 9 February 2006, p. 8. The IAEA reports that as of 3 January 2006, 262 tonnes of HEU had been down-blended and 7 670 tonnes of LEU had been delivered to the US. These deliveries represent 10 467 nuclear warheads. It is expected that 20 000 warheads will be dismantled over the life of the Agreement. See: IAEA and OECD-NEA, *Uranium 2005: Resources, Production and Demand*, *op. cit.*, p. 65.

125 MAPW (WA Branch), *op. cit.*, p. 4.

126 GA, *Exhibit no. 61, op. cit.*, p. 11. The IAEA and OECD-NEA and the WNA reports contain forecasts for secondary sources of supply.

127 The Hon Alexander Downer MP, *op. cit.*, pp. 4–5.

agreement is expected.[128] Summit Resources argued that while secondary sources, particularly the downblending of weapons grade material 'will continue for some time … it is diminishing in its contribution and the industry is expanding. So a large shortfall of uranium is coming.'[129]

2.126 Evidence suggested however that there may be additional secondary supplies released on to the market. For instance, ABARE noted that the US and Russian Federation are each committed to holding stockpiles of some 26 000 tonnes of U_3O_8 until 2009, which could then be released to the market. The availability or unavailability of these secondary supplies could significantly influence the uranium spot market, although ABARE commented that should the US decide to release its stockpiles it is expected that it would do so in a manner that would minimise market impact.[130]

Primary production

2.127 The WNA describes four key periods in the history of uranium mine production:

- a military era, from 1945 to the late 1960s, in which production rose rapidly to satisfy military requirements for HEU and plutonium. Demand from this source fell away sharply from 1960 onwards and production halved by the mid 1960s;
- a period of rapidly expanding civil nuclear power, lasting from the late 1960s to the mid 1980s, in which uranium production rose again as reactors were ordered. Production peaked in 1980 and stayed above annual reactor requirements until 1985;
- a period dominated by inventory over-hang, extended by supply from the Newly Independent States, lasting from the mid 1980s up to 2002; and
- the current period, which commenced in 2003, in which the market has reacted strongly to the perception that secondary supplies are beginning to run out and that primary production needs to rise sharply to fill more of the gap still evident with reactor requirements.[131]

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128 Mr John Carlson (ASNO), *Transcript of Evidence*, 10 October 2005, p. 20; UIC, *Submission no. 12*, p. 30; GA, *Submission no. 42,* p. 5; WNA, *The Global Nuclear Fuel Market – Supply and Demand 2005–2030*, *op. cit.*, p. 167.

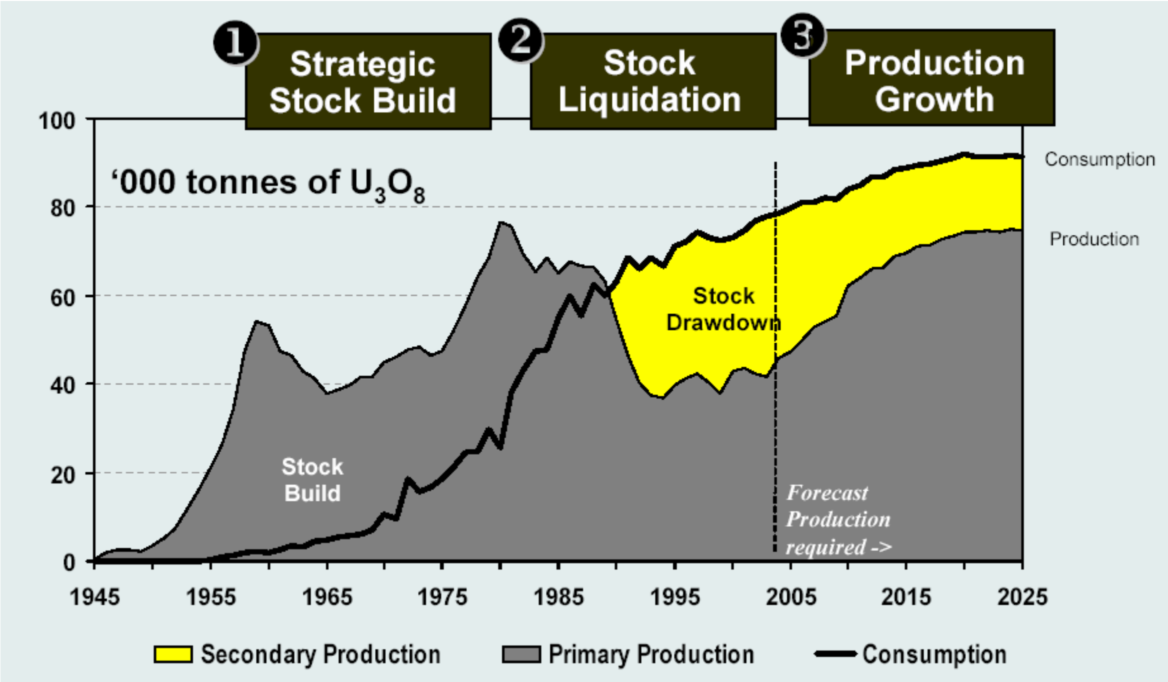
129 Mr Alan Eggers (Summit Resources Ltd), *Transcript of Evidence*, 3 November 2005, p. 2.

130 Mr Will Mollard, *op. cit.*, p. 13. See also: ABARE, *Australian Commodities: Forecasts and Issues*, vol. 13, no. 3, September Quarter 2005, ABARE, Canberra, September 2005, p. 504.

131 WNA, *The Global Nuclear Fuel Market – Supply and Demand 2005–2030*, *op. cit.*, p. 99; Mr Donald Perkin, *op. cit.*, pp. 14, 42.

2.128 Figure 2.6 depicts uranium oxide consumption and production from 1945 to the present and includes a forecast developed by WMC Resources (acquired by BHP Billiton in July 2005) to 2025. The periods of production history listed above are evident in the diagram.

Figure 2.6 Uranium oxide consumption and production from 1945 and forecast to 2025



Source WMC Resources Ltd, *Olympic Dam's Position in the World Uranium Industry*, Presentation by Mr Andrew Michelmore, December 2004, p. 12.

2.129 The WNA's assessment was corroborated in evidence which argued that the industry anticipates that secondary supplies are beginning to run out and that primary production must now rise to meet demand. Specifically, the UIC stated that the proportion of uranium demand met by secondary supplies is expected to fall from 41 per cent in 2004 to about 17 per cent in 2025, and hence 'additional primary production will be needed to meet uranium demand.'[132]

2.130 Similarly, GA argued that:

> … there is an emerging consensus that, by about 2020, there will be a considerably greater requirement for primary uranium from mine production. Given the long lead times for environmental clearances and permitting of new uranium mines, new discoveries will be needed in the short to medium term.[133]

132 UIC, *Submission no. 12*, p. 8. See also: Cameco Corporation, *op. cit.*, p. 3.

133 Mr Aden McKay (GA), *Transcript of Evidence*, 5 September 2005, p. 4.

2.131 Areva also argued that the decline in secondary supplies will require the discovery of more uranium resources and additional production:

> There is no doubt that the weapons grade material coming on stream to be used as fuel was equivalent to several new world-class uranium deposits … When that stops— and the world's energy needs will continue to increase—that part of the supply will basically diminish and it will gradually disappear over a few years. Therefore, we will have to find significantly more resources and reserves to mine in order to fill that gap. Every year, the uranium usage in power plants is increasing reasonably significantly. The number of power plants being [constructed] or on order at this point in time is certainly quite high compared with what it has been over the previous 10 years. The requirement for uranium will become very significant over time and suddenly this supply will not be there any more.[134]

2.132 Paladin Resources argued that:

> World demand for uranium to provide fuel for existing and new plants now under construction exceeds world uranium production twofold … There is ample evidence that the inventory disposals are coming to an end and the industry must now elicit new uranium supplies to meet present demand and to underwrite future nuclear power expansion.[135]

2.133 Heathgate Resources, owners of the Beverley uranium mine in South Australia, submitted that:

> For the first time in 30 years, the uranium business is moving towards primary production. The need to resume uranium exploration is required in order to find and develop more low cost uranium reserves and resources.[136]

2.134 ASNO argued that because of diminishing secondary supplies:

> Clearly expansion of the international uranium mining industry will be required to meet future demand even if there is no significant expansion of the nuclear power industry.[137]

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134 Mr Stephen Mann (Areva), *Transcript of Evidence*, 23 September 2005, p. 8; Areva, *loc. cit.*

135 Paladin Resources Ltd, *loc. cit.*

136 Heathgate Resources Pty Ltd, *Submission no. 49*, p. 1.

137 The Hon Alexander Downer MP, *loc. cit.* See also: Dr Clarence Hardy (ANA), *Transcript of Evidence*, 16 September 2005, p. 52; Summit Resources Ltd, *op. cit.*, p. 20; Dr Rod Hill (CSIRO), *Transcript of Evidence*, 19 August 2005, p. 1.

2.135 Drawing on analysis by iNi, the UIC argued that because of the decline in secondary supply, between 2004 and 2020, annual primary production of uranium oxide will have to rise by nearly 28 000 tonnes, or 60 percent, to 74 500 tonnes in order to meet demand.[138]

2.136 The view that primary production must rise to meet future requirements was supported by the WNA, which concludes that:

> The ending of the HEU deal between Russia and the United States in 2013 may prove to be a major watershed, and it is clear that primary production must rise substantially to make up the loss of this source of supply.[139]

2.137 Moreover, in its forecasts of world uranium requirements and supply to 2030, the WNA argues:

> It is clear … that, in addition to current uranium reserves, there is a requirement for the discovery of new uranium deposits to meet demand in the longer term future.[140]

2.138 Similarly, the IAEA and OECD-NEA state that projected primary production capability to 2025 indicates that secondary sources will continue to be needed to meet projected requirements. The 2005 Red Book states that after 2015 secondary sources are expected to decline in availability and that reactor requirements will have to be increasingly met by expanding production from existing mines, developing new mines or introducing alternate fuel cycles:

> A sustained near-term strong demand for uranium will be needed to stimulate the timely development of needed Identified Resources. Because of the long lead-times required to identify new resources and to bring them into production (typically in the order of 10 years or more), there exists the potential for the development of uranium supply shortfalls and continued upward pressure on uranium prices as secondary sources are exhausted. The long lead times required to bring resources into production continues to underscore the importance of making timely decisions to increase production capability well in advance of any supply shortfall.[141]

138 UIC, *Submission no. 12*, pp. 3, 8.

139 WNA, *The Global Nuclear Fuel Market – Supply and Demand 2005–2030*, *op. cit.*, p. 4.

140 *ibid.*, p. 182.

141 IAEA and OECD-NEA, *Uranium 2005: Resources, Production and Demand*, *op. cit.*, p. 11; ERA, *op. cit.*, p. 3. Canada's Uranium Production & Nuclear Power

Uranium price

2.139 Nova Energy stated that the relative availability of primary and secondary sources of supply of uranium, combined with the level of demand from military and civilian users have determined the market price for mined uranium since the 1940s. Nova Energy cited research which identifies three distinct periods of uranium price history:

- a weapons procurement era (1940–1969);
- an inventory accumulation era (1970–1984); and
- an inventory liquidation period (1985–2004).[142]

2.140 During the weapons procurement and inventory accumulation periods uranium was supplied almost entirely from mine production and the average spot market price was US$54.18/lb U_3O_8 (in 2005 dollars), with a peak of $110/lb U_3O_8 in 1976. During the inventory liquidation era, spot prices fell to an average US$14.57/lb U_3O_8 as secondary sources became available for sale on the market. Nova Energy argued that the effect of the inventory liquidation was to artificially depress the price of uranium in a period when mine supply was declining and demand increasing.[143]

2.141 Market perceptions of diminishing secondary supplies are now a significant influence on the uranium price. Areva stated that the gradual depletion of secondary supplies is now placing considerable upward pressure on spot prices for uranium, which doubled from year-end 2002 to year-end 2004. In the period since, the uranium spot price has more than doubled again.[144]

2.142 GA noted that, in addition to a decrease in the availability of HEU from the Russian Federation, the price increase has been due to very high world oil prices, temporary reductions in mine supply due to the flooding of the McArthur River mine in Canada, and damage to the metallurgical plant at Olympic Dam caused by fires in 2003.[145]

2.143 ASNO observed that because the demand for uranium is relatively inelastic with respect to the price of natural uranium supply, there is expected to be a major increase in price as the inventory drawdown process comes to an end. Reprocessing capacity limitations would also prevent recycled uranium or plutonium from substantially affecting such price rises.[146]

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142 Nova Energy Ltd, *loc. cit.*

143 *ibid.*, pp. 4–5.

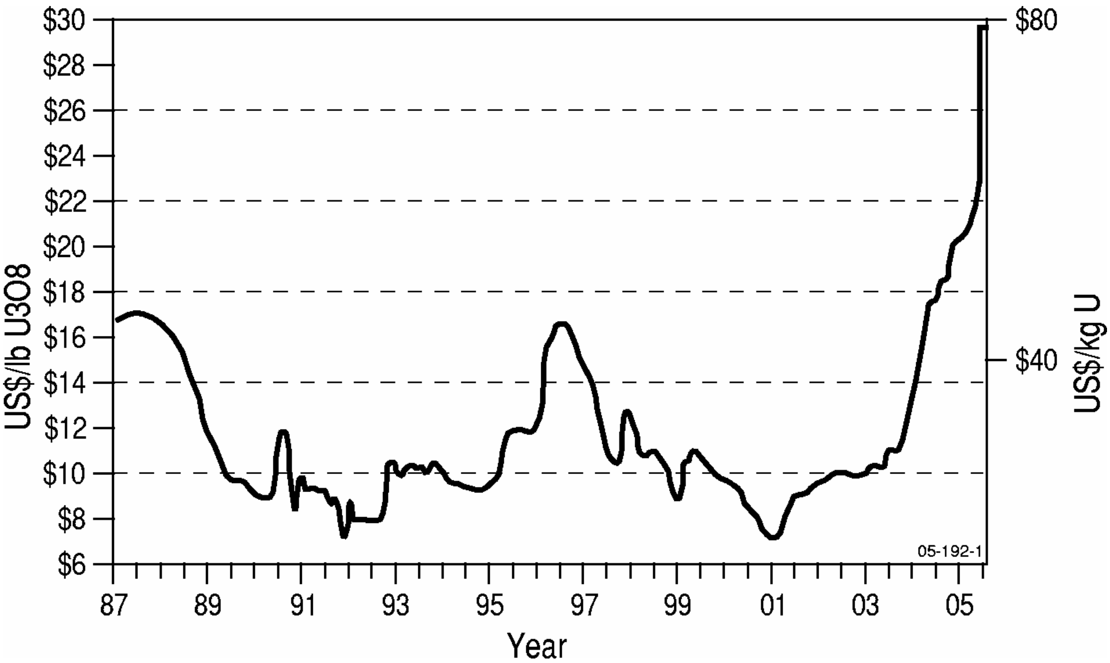
144 Areva, *loc. cit.*

145 GA, *Submission no. 42*, p. 5.

146 The Hon Alexander Downer MP, *op. cit.*, p. 5.

2.144 During the course of the Committee's inquiry, the spot price for uranium oxide doubled from approximately US$22 per pound U_3O_8 to US$44/lb U_3O_8.[147] The spot market prices for uranium since 1988, in both US$/kg U and US$/lb U_3O_8, are shown in figure 2.7.

Figure 2.7 Spot market prices for uranium



Source Geoscience Australia, *Exhibit no. 61*, *Australia's uranium resources and exploration*, p. 8 (Ux Consulting Company, LLC).

2.145 The IAEA and OECD-NEA explain that the over-production of uranium to 1990, combined with availability of secondary sources, resulted in prices trending downwards from the early 1980s until 1994 when they reached their lowest point in 20 years. Between 1990 and 1994 the decrease in supply, including exploration and production, saw prices rise modestly. This trend reversed as better knowledge of the state of inventories maintained downward pressure on uranium prices. Beginning in 2001, the price of uranium has rebounded from historic lows to levels not seen since the 1980s.

2.146 Although most uranium is sold under long-term contract rather than on to the spot market, the spot market prices give an indication of the state of the world uranium market in which future contracts will be written. ERA noted that market prices for long-term contracts increased at a faster rate than spot prices during 2003 and 2004 and by December 2004 the long-

147 From March 2005 to June 2006. Uranium spot prices available from the Ux Consulting Company, LLC, viewed 8 June 2006, <http://www.uxc.com/review/uxc_prices_mth-end.html>.

term indicators had risen to US$25/lb U_3O_8. In the first half of 2005 prices rose even higher, with long-term prices reaching US$30 per pound.[148]

2.147 Nova Energy argued that the tightness in secondary supplies, combined with the long lead times required to discover, gain regulatory approvals and develop new mines or to expand existing facilities means that 'the stage is set for a significant increase in spot and contract prices, perhaps matching or exceeding the highs of 1976.'[149]

2.148 The price of natural uranium is unlikely to significantly affect the cost of nuclear fuel or the overall cost of the electricity generated because the mined cost represents only a quarter of the cost of the fuel loaded into a reactor.[150] The economics of nuclear power are discussed further in chapter four.

2.149 The substantial increase in the uranium price can be expected to stimulate expansion of existing mines as well as exploration for uranium. The rise in price will also mean that the economics of known, but economically less attractive, orebodies will improve, leading to development of new mines.[151]

2.150 Dr Donald Perkin explained the relationship between the uranium price, exploration activity and production as follows:

> … a real increase in commodity price results in an increase in exploration activity; increases in exploration expenditure begin almost immediately the price starts to rise and exploration activity tends to reach its maximum about two years after the commodity price peaks. Increases in prices and in levels of exploration expenditure over time leads to a significant increase in the level of known economic resources because of the higher rate of discovery of new ore deposits … as well as through the addition of some previously known sub-economic resources reclassified into the economically viable category … Production of U_3O_8 increases about a year after commodity prices start to rise and the increases in production lasts well after prices peak, an apparent 'momentum' effect which continues several years into the downturn section of the cycle, due largely to contractual sales arrangements containing fixed … spot prices written into agreements.[152]

148 ERA, *op. cit.*, p. 2.

149 Nova Energy Ltd, *op. cit.*, p. 7.

150 UIC, *Submission no. 12*, p. 30.

151 ANSTO, *Submission no. 29*, p. 4.

152 Dr Donald Perkin, *Exhibit no. 3, The significance of uranium deposits through time*, Abstract, p. 2.

World uranium production and resources

Uranium resources and production by country

2.151 In 2005, uranium was mined in 17 countries with the top 12 countries producing 99 per cent of the total output.[153] The quantity produced in each of these countries and the share of the world total for 2002–05 are listed in table 2.2.

2.152 Australia and Canada combined accounted for 50.5 per cent of world uranium production in 2005. Canada produced 11 628 tU, while Australian mines produced 9 522 tU.[154]

2.153 Production in 2005 represented a three per cent increase on the previous year's total. ABARE have forecast that world mine production will again rise modestly in 2006, as increases in Canada and China will be partly offset by the expected closure of a mine in the Czech Republic.[155]

2.154 GA and other submitters noted that the Athabasca Basin in northern Saskatchewan, Canada contains a number of extremely high-grade deposits, such as Macarthur River and Cigar Lake, with ore grades up to 20 per cent uranium. In contrast, the average ore grade at Olympic Dam in South Australia is 0.04 per cent uranium.[156]

2.155 Kazakhstan also contains significant uranium deposits and while the logistics are thought to be difficult, the deposits are now being developed through joint ventures with foreign companies. Several deposits in Kazakhstan are amenable to ISL mining. Mongolia also contains significant known mineralisation and exploration and mining activity is taking place in Niger and Namibia.[157]

153 RWE NUKEM, *op. cit.*, p. 12. For 2004 production figures see IAEA and OECD-NEA, *Uranium 2005: Resources, Production and Demand*, *op. cit.*, pp. 28–29.

154 *ibid*.

155 ABARE, *op. cit.*, pp. 6–7.

156 Dr Ian Lambert (GA), *Transcript of Evidence*, 5 September 2005, p. 13; Mr Andrew Parker, *Submission no. 35*, p. 10.

157 Dr Ian Lambert, *op. cit.*, pp. 7–9; Mr Stephen Mann (Areva), Transcript of Evidence, 23 September 2005, p. 2; Paladin Resources Ltd, *Submission no. 47*, p. 2.

Table 2.2 World uranium production by country, 2002–2005

Country	2002		2003		2004		2005	
	tonnes U	Share of total (%)	tonnes U	Share of total (%)	tonnes U	Share of total (%)	tonnes U	Share of total (%)
Canada	11 607	32.0	10 446	29.4	11 596	28.5	11 628	27.8
Australia	6 854	18.9	7 595	21.4	9 406	23.1	9 522	22.7
Kazakhstan	2 834	7.8	3 150	8.9	3 719	9.1	4 357	10.4
Russia	3 000	8.3	3 158	8.9	3 200	7.9	3 431	8.9
Namibia	2 333	6.5	2 036	5.7	3 038	7.5	3 147	8.2
Niger	3 076	8.5	3 095	8.7	3 282	8.1	3 093	7.4
Uzbekistan	1 860	5.1	1 545	4.4	2 050	5.0	2 300	5.5
United States	883	2.4	779	2.2	877	2.2	1 039	2.5
Ukraine	1 100	3.0	1 000	2.8	800	2.0	800	1.9
China	500	1.4	750	2.1	750	1.8	750	1.8
South Africa	824	2.3	758	2.1	754	1.8	673	1.6
Czech Republic	465	1.3	346	1.0	412	1.0	108	1.0
Subtotal	*35 336*	*97.6*	*34 863*	*97.7*	*34 863*	*98.1*	*41 490*	*99.0*
Others*	859	2.4	835	2.3	773	1.9	380	1.0
TOTAL	**36 232**	**100.0**	**35 688**	**100.0**	**40 657**	**100.0**	**41 870**	**100.0**

Source RWE NUKEM, *NUKEM Market Report*, May 2006, p. 14.
* Other producing countries include: Brazil, Germany, India, Pakistan and Romania.

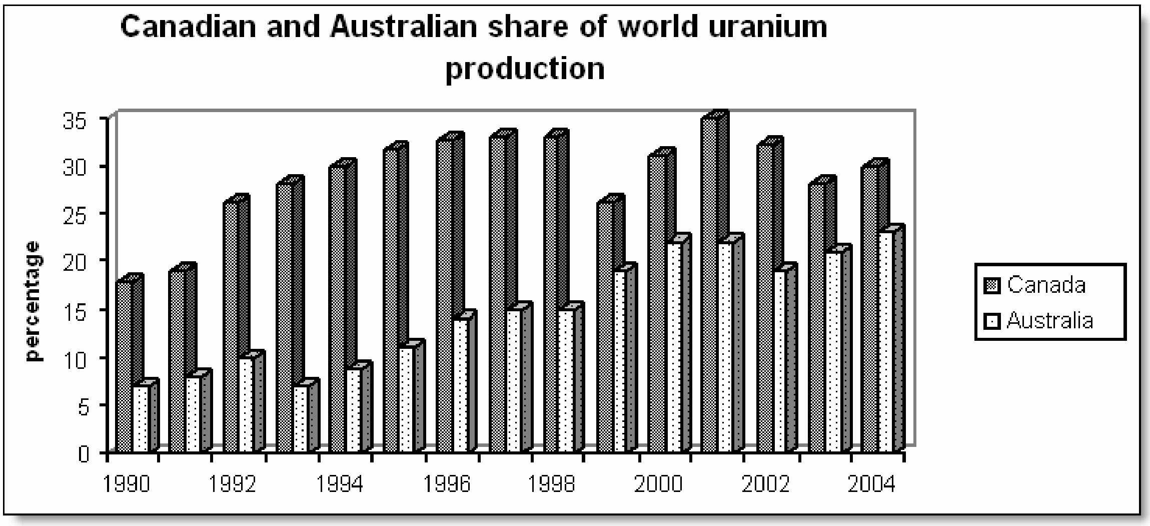
2.156 Australia produces less uranium than its proportional share based on its resources. Australia has the world's largest resources in what the IAEA and OECD-NEA classify as Reasonably Assured Resources (RAR) recoverable at less than US$40/kg U, or 'low cost'. In December 2005, Australia's resources were estimated to be 716 000 tU, which represents 36 per cent of world resources in this category. Other countries with large resources include Canada (15 per cent), Kazakhstan (14 per cent), Niger (9 per cent), Brazil (7 per cent), South Africa (5 per cent), Uzbekistan (4 per cent), Namibia (3 per cent) and Russian Federation (3 per cent).[158] Thus, while Australia possesses some 36 per cent of the world's uranium resources, it currently produces only 23 per cent of world mine output.[159]

158 IAEA and OECD-NEA, *Uranium 2005: Resources, Production and Demand*, *op. cit.*, p. 15; GA, *Submission no. 42*, pp. 15, 16. Updated resource figure to December 2005 provided by Mr Aden McKay (GA).

159 Nova Energy Ltd, *op. cit.*, p. 9.

2.157 Canada has less than half of the uranium resources of Australia but its annual production has been substantially higher, as depicted in figure 2.8.[160]

Figure 2.8 Canadian and Australian shares of world uranium production (1990–2004)



Source UIC, *Submission no. 12*, p. 9.

Uranium production by company

2.158 The world's three largest producers of uranium in 2005 were, in decreasing order of production, Cameco, Rio Tinto/ERA and Areva. WMC Resources, now owned by BHP Billiton, was the fifth largest producer in 2005, with 8.8 per cent of world production. Uranium production by company is listed in table 2.3.

2.159 The three largest producers each account for between 12–20 per cent of total uranium production worldwide. Combined, the ten largest producers represent approximately 75 per cent of world production.[161]

2.160 Cameco is the world's largest producer of uranium and accounts for almost 20 per cent of world production, with four operating mines in Canada and the US. Cameco owns the world's largest high-grade uranium deposit at McArthur River, Saskatchewan, along with mines at Key Lake and Rabbit Lake. In 2004, the McArthur River mine produced 7 200 tU, or almost 18 per cent of world production. Cameco has a 50 per cent interest

160 Further information on Canada's uranium production available from UIC, *Canada's Uranium Production and Nuclear Power*, Nuclear Issues Briefing Paper No. 3, viewed 12 June 2006, <http://www.uic.com.au/nip03.htm>.

161 Areva, *op. cit.*, p. 9. See also: UIC, *World Uranium Mining*, Nuclear Issues Briefing Paper No. 41, viewed 12 June 2006, <http://www.uic.com.au/nip41.htm>.

in the world’s second largest high-grade uranium deposit at Cigar Lake in Saskatchewan, which is expected to commence production in late 2007.[162]

Table 2.3 World uranium production according to shareholder, 2004–2005

Company	2004		2005	
	tonnes U	Share of total (%)	tonnes U	Share of total (%)
Cameco	8 310	20.4	8 275	19.8
Rio Tinto	5 335	13.1	5 583	13.3
Areva	5 666	13.9	5 174	12.4
KazAtomProm	3 582	8.8	4 032	9.6
BHP Billiton (WMC Resources)	3 735	9.2	3 688	8.8
TVEL	3 200	7.9	3 431	8.2
Navoi	2 050	5.0	2 300	5.5
ONAREM (Niger)	1 089	2.0	1 032	2.5
General Atomics	919	2.3	875	2.1
NPV Vostok	800	2.0	800	1.9
CNNC	750	1.8	750	1.8
Anglo Gold	754	1.9	673	1.6
Denison	520	1.3	475	1.1
Subtotal	*36 710*	*90.3*	*37 089*	*88.6*
Others	3 947	9.7	4 781	11.4
TOTAL	**40 657**	**100.0**	**41 870**	**100.00**

Source RWE NUKEM, *NUKEM Market Report*, May 2006, p. 19.

2.161 ABARE informed the Committee that Cameco planned to increase production at its three Canadian mines by over three per cent in 2005 and that this increase could be larger if proposed capacity increases at McArthur River and Key Lake were approved. Cameco has applied for a licence to increase combined annual production at these mines by 18 per cent. However, the *RWE NUKEM Market Report* of May 2006 indicates that the review process was not progressing as rapidly as the company had hoped and consequently the proposed expansion may not be in place until 2007 or 2008.[163] The expected level of Cameco’s total production capacity has also been boosted by an extension of the Rabbit Lake mine life to 2007 after additional reserves were identified.[164]

2.162 Rio Tinto, through its shareholdings in ERA (68 per cent) and Rössing Uranium in Namibia (69 per cent), was the second largest producer in

162 Cameco Corporation, *op. cit.*, p. 1; Cameco Corporation, *Profile*, viewed 12 June 2006, <http://www.cameco.com/investor_relations/profile/>.

163 RWE NUKEM, *op. cit.*, p. 14.

164 ABARE, *op. cit.*, p. 6.

2005, with an estimated 5 583 tU. ERA's Ranger mine in the Northern Territory produced 5 006 tU, which represented 12 per cent of world production in 2005. Ranger was the world's second largest mine by production in 2005 and the world largest uranium mines are listed in table 2.4.[165]

Table 2.4 The world's largest uranium mines 2004–2005, by production

Mine	Country	Main owner	2004		2005	
			tonnes U	Share of total (%)	tonnes U	Share of total (%)
McArthur River	Canada	Cameco	7 200	17.7	7 200	17.2
Ranger	Australia	ERA (Rio Tinto 68%)	4 753	11.7	5 006	12.0
Olympic Dam	Australia	BHP Billiton	3 735	9.2	3 688	8.8
Krasnokamensk	Russia	TVEL	3 000	7.4	3 300	7.9
Rössing	Namibia	Rössing Uranium (Rio Tinto 69%)	3 038	7.5	3 147	7.5
Rabbit Lake	Canada	Cameco	2 087	5.1	2 316	5.5
McClean Lake	Canada	Areva	2 310	7.9	2 112	5.0
Akouta	Niger	Areva/Onarem	2 005	4.9	1 778	4.2
Arlit	Niger	Areva/Onarem	1 277	3.1	1 315	3.1
Beverley	Australia	Heathgate Resources (General Atomics)	919	2.3	875	2.1
Vaal River	South Africa	Anglogold	754	1.9	673	1.6

Source RWE NUKEM, *NUKEM Market Report*, May 2006, pp. 17, 19; UIC, *World Uranium Mining*, Nuclear Issues Briefing Paper No. 41.

2.163 Areva is the only Group active in all stages of the nuclear fuel cycle and in 2004 was the world's second largest producer of uranium, with a market share of 12 470 tU sold and an output of 6 125 tU in 2004. Areva owns 142 000 tU in uranium reserves, which are equal to 20 times its 2004 production. The company's total underground mineral resources, including reserves, amount to approximately 490 000 tU. Areva also has access to the equivalent of 26 000 tU during the 2004 to 2013 timeframe of the HEU Purchase Agreement.[166]

2.164 Areva submitted that it owns uranium resources and conducts operations in Canada, Niger and Kazakhstan and the company expects to benefit from the renewed demand for primary production. From 2010 Areva intends to achieve combined annual production of some 4 000 tU per year from its deposits in Kazakhstan and Cigar Lake in Canada. The company

165 UIC, *World Uranium Mining, loc. cit*; RWE NUKEM, *op. cit.*, p. 20.

166 Areva, *op. cit.*, pp. 8, 10, 11.

explained that for each deposit it takes some 10–15 years from the first phases of exploration to the commencement of mining, with an average cost of €50 million per deposit. In 2004, Areva's exploration and mine development expenditure amounted to €16 million.[167]

2.165 The ten largest uranium mines in the world produced over 73 per cent of world output in 2005. These facts support the WNA's conclusion that:

> Firstly, uranium production is becoming increasingly concentrated in a small number of large mines in a limited number of countries, particularly Canada and Australia. Secondly, ownership of the major mines is becoming concentrated in a smaller number of companies…[168]

Adequacy of world uranium resources to meet long-term growth in nuclear capacity

2.166 Several submitters argued that world uranium resources are insufficient to support an expansion of nuclear capacity and, hence, that nuclear power represents at best a 'temporary response' to addressing climate change.[169] For example, FOE argued that:

> Relatively high-grade, low-cost uranium ores are limited and will be exhausted in about 50 years at the current rate of consumption. The estimated total of all conventional uranium reserves is estimated to be sufficient for about 200 years at the current rate of consumption. These resources will of course be depleted more rapidly in a scenario of nuclear expansion. It is far from certain that uranium contained in 'unconventional sources' such as granite, sedimentary rock or seawater can be recovered economically.[170]

2.167 Similarly, Mr Justin Tutty argued that:

> At the current rate of consumption, low cost uranium reserves will be exhausted in around 50 years. To maintain nuclear's share of the energy market, these reserves would be exhausted faster, as global energy demand is continuing to grow. If nuclear is actually meant to displace *future* fossil fuel use, then these reserves will be exhausted faster still. If nuclear is also intended to displace *current*

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167 *ibid.*, p. 10.

168 WNA, *The Global Nuclear Fuel Market – Supply and Demand 2005–2030, op. cit.*, p. 3.

169 See for example: FOE et. al., *Exhibit no. 71, Nuclear Power: No Solution to Climate Change*, section 2.2; People for Nuclear Disarmament NSW Inc, *Submission no. 45*, p. 5; NT Greens, *Submission no. 9*, p. 1; APChem, *Submission no. 38*, p. 3.

170 FOE, *Submission no. 52*, p. 5.

> fossil fuel use, then these reserves clearly won't stretch far into the future.[171]

2.168 The ACF likewise argued that if all electricity currently generated by fossil fuels were replaced by nuclear power, 'there would be enough economically viable uranium to fuel reactors for between 3 and 4 years.'[172]

2.169 Other evidence rejected arguments of scarcity of world uranium supply in the longer-term. For example, Compass Resources argued that: 'Uranium is not, nor is likely to be, in short supply in the long term' and Mr Andrew Crooks asserted that: 'The reality is there is plenty of proven and probable uranium resources to last the world for several thousand years.'[173]

2.170 Mr Keith Alder, former General Manger and Commissioner of the Australian Atomic Energy Commission, argued that concerns about the future supply of uranium were first raised in the mid 1950s and have proved false. Concerns about an impending uranium shortage encouraged research into fast breeder reactors (FBRs) which can extend the energy extractable from a given quantity of uranium by up to a factor of 50. However, Mr Alder noted that:

> … it turned out that there was plenty of uranium … The antinuclear people often say, 'It's a stopgap exercise because we will run out of uranium.' That is absolute rubbish. There is an awful lot of uranium still to be discovered, particularly in Australia. I draw your attention to the Northern Territory … nobody has really had an extensive look very deep underground in the Northern Territory, and that is just one part of Australia.[174]

2.171 Mr Andrew Parker also argued that estimates of reserves lasting only a few decades are misleading because until recently there has been relatively little new exploration:

> It is not known how long the reserves will last because the funding of uranium exploration is many years and billions of dollars behind and no where near as comprehensive and complete as exploration for oil and gas. Indeed some of richest uranium deposits have only recently been discovered whereas all the really big oil fields were discovered over 40 years ago. It is likely that many more high-grade uranium deposits will be found and it has been estimated that the ultimate resource base is far larger.[175]

171 Mr Justin Tutty, *Submission no. 41*, p. 3. Emphasis in original.

172 ACF, *op. cit.*, p. 13.

173 Compass Resources NL, *op. cit.*, p. 2; Mr Andrew Crooks, *Submission no. 84*, p. 4.

174 Mr Keith Alder, *Transcript of Evidence*, 16 September 2005, p. 81.

175 Mr Andrew Parker, *loc. cit.*

2.172 The ANF also observed that:

> Of course more reserves are certain to be discovered albeit at higher recovery costs, but fuel costs are not a large contributor to generating costs so the basic 50 year figure is probably conservative.[176]

2.173 BHP Billiton also noted that the price of nuclear generated electricity is not sensitive to uranium price, so the requirement to mine uranium recoverable at higher costs is not a major issue:

> … the cost of fuel in nuclear power generation is not a very high proportion of the total cost, and the generators are not particularly sensitive to the actual cost of uranium in their calculations. That means that a decade ago they were quite prepared to sign long-term contracts at significantly above the spot price, because they were more interested in security of supply than they were in the price. The price was not really driving the economics of nuclear power generation.
>
> In the meantime, demand has grown and mine output has not grown all that much, so the spot is now above the long-term contract price, and again the generators are not particularly worried about paying a high spot, because even now, at $30 a pound on the spot, it is not a very high proportion of the total cost of operating nuclear power stations.[177]

2.174 Similarly, Mr Alistair Stephens of Arafura Resources argued that the effect of a rise in uranium price is to make previously uneconomic resources viable for commercial use and to encourage greater exploration:

> The calculation that there are only 50 years of uranium resources left is made on the basis of the supply and demand relationship, so the grade of concentration of uranium in currently known resources that could be economically extracted would last 50 years. If the price of uranium were to increase, the amount of resources that are known would increase, so our supply of product would increase. That calculation also does not account for the fact that exploration will, in all probability, find new sources of uranium that could be used for injection into the supply relationship.[178]

2.175 The 2005 Red Book states that total Identified Resources (which includes RAR and Inferred Resources recoverable at costs of less than US$130/kg

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176 ANF, *Exhibit no. 5, Uranium Mining in Australia*, p. 1; ANF, *Submission no. 11*, p. 2.

177 Dr Roger Higgins (BHP Billiton Ltd), *Transcript of Evidence*, 2 November 2005, p. 21.

178 Mr Alistair Stephens (Arafura Resources NL), *Transcript of Evidence*, 23 September 2005, p. 53.

U) amounts to 4.7 million tU. The IAEA and OECD-NEA state that these resources are sufficient to supply the current once-through fuel cycle for 85 years at 2004 rates of consumption.[179]

2.176 Total Conventional Resources (which includes all cost categories of Identified Resources plus Prognosticated and Speculative Resources) amounts to some 14.8 million tU. With the once-through fuel cycle, these resources are estimated to be sufficient for 270 years at current rates of consumption.[180]

2.177 Unconventional Resources, which includes uranium that can be recovered from phosphate deposits, seawater and black shale, would add another 22 million tU, bringing total uranium available for exploitation to over 35 million tU. Combining Conventional Resources with the uranium in phosphates would provide sufficient uranium to fuel 675 years of electricity generation at current rates of consumption. The IAEA and OECD-NEA thus conclude that 'sufficient nuclear fuel resources exist to meet energy demands at current and increased demand well into the future.'[181]

2.178 Mr Alder pointed out that the Japanese Government previously studied the extraction of uranium from seawater and while the cost was about eight to ten times the cost of mined uranium at the time of the study, 'they calculated that there is 4,000 million tonnes of uranium in the sea. I cannot see this world running out of uranium fuel.'[182] Moreover, as noted by BHP Billiton and Arafura Resources above, because the cost of uranium is a small proportion of the overall price of nuclear generated electricity, Mr Alder argued that:

> Even if it did cost five to 10 times the [current] price of uranium, if you look at the cost of the uranium that goes into the production of a kilowatt hour you see that it is negligible. If you multiplied the cost of uranium in the kilowatt hour by 10, the householder or the small industrial user would face a very small increase in power price.[183]

2.179 The IAEA and OECD-NEA reinforce the observations of submitters cited above, that exploration is highly likely to find new discoveries and expand the uranium resource base. Indeed, the 2005 Red Book reports that the rise in spot price has stimulated major new exploration activity, with worldwide exploration expenditure in 2004 totalling over US$130 million,

179 IAEA and OECD-NEA, *op. cit.*, pp. 361–365, 14.

180 *ibid.*, p. 21.

181 *ibid.*, p. 78.

182 Mr Keith Alder, *loc. cit.*

183 *ibid.*

a 40 per cent increase on the 2002 figure. Exploration expenditure in 2005 is expected to approach $200 million.[184]

2.180 The WNA, which has published a position statement on future uranium supplies, lists additional sources of nuclear fuel, including:

- reprocessing used nuclear fuel to recover unburned fissile material, which can increase the efficiency of uranium utilisation by up to 30 per cent (as noted above, reprocessing currently provides only 3 per cent of world nuclear fuel supply);
- increasing the enrichment level of fuel, which can save uranium use in reactors;
- using thorium, which is four times more abundant than uranium in the Earth's crust[185];
- greater fuel efficiency in advanced reactor designs, currently being developed in multinational research programs, which may be deployed beyond 2030; and
- using fast neutron reactors (FNRs) (of which FBRs are one sub-type), which utilise the U-238 component of natural uranium, as well as the existing stock of depleted uranium, by converting non-fissile U-238 to ('breed') fissile plutonium.[186]

2.181 ASNO explained that the development of the fast neutron fuel cycle will allow the most efficient use of uranium resources. Currently, the 'thermal' nuclear fuel cycle, typified by the LWR, is an extremely inefficient use of uranium resources, generating energy from the fissile isotope U-235 which comprises only 1/140th of natural uranium (i.e. 0.71 per cent of natural uranium is U-235). The once-through cycle will consume available supplies of uranium far more quickly because all used fuel is treated as waste for disposal. In contrast, the basis of the fast neutron cycle is the use of fast (unmoderated) neutrons to convert the predominant uranium isotope U-238 to plutonium as reactor fuel.[187] Theoretically, this could extend the energy value of uranium by up to a factor of 140, thereby making existing uranium reserves sufficient for several thousand years.

2.182 The 2005 Red Book reports that use of fast reactor technology, which is already proven, offers the prospects of multiplying uranium resources 50-fold. In this way, use of nuclear energy at current consumption levels may be extended by over 2 500 years based on Identified Resources, to over

184 IAEA and OECD-NEA, *op. cit.*, pp. 9, 25.

185 Australia's resources of thorium are described in the following chapter.

186 WNA, *Can uranium supplies sustain the global nuclear renaissance?*, WNA, London, 2005, pp. 6–7, viewed 13 June 2006, <http://www.world-nuclear.org/position/uranium.pdf>.

187 ASNO, *Exhibit no. 93, Notes to accompany an informal briefing on the GNEP initiative*, p. 6.

8 000 years with currently known Conventional Resources and to almost 20 000 years with total Conventional Resources and phosphates.[188]

2.183 Similarly, the ANF also argued that if FBRs became widely adopted the market demand for uranium may reduce because:

> Breeder reactors will extend uranium utilisation by about a factor of 60; in other words, rather than 50 years, the quantity of world reserves … will last for another 3 000 years. Also, if the 2.1 million tonnes of uranium already mined are taken into account (most of the U238 still remains) then the total rises to nearly 5 000 years.[189]

2.184 Despite the promise of breeder reactors in extending uranium utilisation, FOE argued that most FBR programs have been abandoned:

> Accepting that low-cost uranium resources are limited, nuclear advocates frequently argue that the use (and production) of plutonium in 'fast breeder' reactors will allow uranium resources to be extended almost indefinitely. However, most plutonium breeder programs have been abandoned because of technical, economic and safety problems.[190]

2.185 The ACF also argued that FBRs have been a 'technological and economic failure', but conceded that 'with use of fast breeder reactors a closed cycle could be reached that would end the dependency on limited uranium resources.'[191]

2.186 ASNO previously acknowledged that that despite the energy (and waste management) advantages of the fast neutron cycle, the development of FNRs has been slow for economic reasons, engineering complications and public concerns about the safety of conventional FBRs.[192]

2.187 However, evidence indicated that there is now renewed interest in plutonium recycling. ASNO informed that Committee that, having been committed to the once-through fuel cycle since the Carter Administration, the US is now embracing plutonium recycling because of its more efficient utilisation of uranium.

2.188 Through its recently announced Global Nuclear Energy Partnership (GNEP) initiative, the US intends that so-called 'fuel supplier' nations will use FNRs and advanced spent fuel separation, which will recycle plutonium and transmute longer-lived radioactive materials. These technologies will recycle plutonium *without* requiring plutonium

188 IAEA and OECD-NEA, *op. cit.*, p. 78.

189 ANF, *loc. cit.*

190 FOE, *Submission no. 52*, *loc. cit.*

191 ACF, *loc. cit.*

192 ASNO, *Exhibit no. 93, loc. cit.*

separation, which will meet the concern of some submitters that FBRs add to proliferation risks. Current plans by the US Government are to deploy commercial fast reactors in 2040.[193]

Potential for Australia's uranium production to expand

2.189 Evidence to the inquiry emphasised that if policies which are preventing the development of much of the nation's resource base are reversed, Australia will be well placed to expand production and meet the expected growth in uranium demand:

> Australia is well positioned in terms of its identified resources to take advantage of the expected growth in demand for uranium and expected increase in uranium prices. Australia has about one third of the world's low cost uranium. Seven of the top 20 known uranium deposits in the world are in Australia.[194]

2.190 Examples of observations by submitters making this argument include:

- 'Australia is already a significant supplier of uranium – yet the growing demand is providing an unparalleled opportunity for Australia to be the dominant supplier of a crucial global commodity.'[195]
- 'Australia is extremely well placed to take advantage of this situation, both in the immediate future and in the long term.'[196]
- 'With reserves twice those of Canada, despite little exploration over the last fifteen years, Australia is in the position of being capable of significantly increasing its uranium production and exports in direct competition with Canada … Additional low-cost mines in Australia would supply a substantial proportion of the needed increase in world output.'[197]
- 'Australia is, and should be, well positioned to capture a large part of this burgeoning market. We have the largest proportion of economic demonstrated resources of any country in the world. Moreover, our resources are the lowest cost uranium resources in the world, being almost entirely recoverable at less than $US29 a pound of U_3O_8.'[198]

193 Dr Ron Cameron, *op. cit.*, p. 11.
194 UIC, *Submission no. 12*, p. 8.
195 Nova Energy Ltd, *op. cit.*, p. 8.
196 Cameco Corporation, *op. cit.*, p. 3.
197 Association of Mining and Exploration Companies (AMEC), *Submission no. 20*, pp. 5–6.
198 Mr Mitch Hooke (MCA), *Transcript of Evidence*, 5 September 2005, p. 21.

2.191 CSIRO also commented that if Australia could source new deposits of uranium and obtain higher levels of recovery from known deposits, it could position itself as the global leader in the industry.[199]

2.192 Compass Resources suggested that Australia's considerable uranium resources potentially places the domestic industry in a similar position to iron ore or alumina:

> Australia is … in a fortunate position that, along with Canada and certain African countries it has substantial high grade resources of uranium that can be produced at relatively low cash costs. In this regard Australia's position for uranium places it with similar advantages to iron ore or alumina, that is it can become one of a limited number of countries that supply a significant proportion of annual world uranium consumption.[200]

2.193 It was also argued that production from other countries may not attract the safeguards and regulatory controls imposed on Australian exports. Nova Energy also argued that the two other countries with major resources, Canada and Kazakhstan, are either not as well regulated or not as well placed to meet the growing demands in the Asian region. Australia was said to be 'uniquely placed – it is geographically well located close to the major growth areas.'[201]

2.194 Similarly, the UIC argued that while Canada has achieved greater annual production than Australia to date and Kazakhstan (which has larger reserves than Canada in the category of RAR recoverable at less than US$80/kg U) is aiming for a fourfold increase in mine production, nonetheless:

> … Australia has good relations with the most rapidly growing markets for uranium, those in East Asia, and is a preferred supplier into those markets.[202]

2.195 AMEC also submitted that with forecast growth in nuclear capacity in East and South East Asia:

> Australia's abundance of uranium reserves will further ensure its future position as a leading world supplier to these markets, provided a politically and economically favourable environment in Australia is maintained.[203]

199 CSIRO, *Submission no. 37*, p. 7.
200 Compass Resources NL, *Submission no. 6*, p. 2.
201 Nova Energy Ltd, *op. cit.*, p. 9.
202 UIC, *Submission no. 12*, p. 9.
203 AMEC, *op. cit.*, p. 6.

2.196 While Australia has some 36 per cent of the world's resources of uranium, it was submitted that the key question remains:

> … whether Australian companies … can expand their production to meet this expected increasing demand and also whether they can export uranium to rapidly developing markets in China and India.[204]

2.197 Paladin Resources argued that sustained higher prices will be required to stimulate production because of the 'extreme tightness of supply extending for up to twenty years', but that:

> Australia will be the prime beneficiary of this new investment, if our uranium policies and regulations are brought into alignment with the realities of the world's civil nuclear power industry.[205]

2.198 Similarly, ANSTO submitted that:

> Prima facie, ANSTO believes that Australia is well placed to respond to increases in demand, given the size of our reserves. ANSTO notes, however, that current policy in some states precludes the development of new mines from known resources, and other states have legislation that prohibits the prospecting for, or the mining of, uranium. It is therefore possible that Australia will not be able to maximise the benefits that could be obtained from its uranium resources.[206]

2.199 Jindalee Resources argued that while 'Australia should be the world leader in the production of uranium', the:

> … current regulatory environment dissuades investment in uranium exploration, favours the entrenched position of three existing producers and leaves limited opportunity for the development of other mines by new entrants. This environment is clearly anti-competitive and has sterilised the majority of Australia's uranium deposits. It is in the National Interest that this environment is changed.[207]

2.200 The following chapter assesses Australia's uranium resources, production and exploration, while the impediments to the development of Australia's uranium resources are addressed in chapter eleven.

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204 Dr Clarence Hardy (ANA), *Transcript of Evidence*, 16 September 2005, p. 52.

205 Paladin Resources Ltd, *loc. cit.*

206 ANSTO, *Submission no. 29*, p. 5.

207 Jindalee Resources Ltd, *op. cit.*, p. 1.

Conclusions

2.201 Nuclear power generates some 16 per cent of the world's electricity. While nuclear's contribution varies, it provides a substantial proportion of national electricity requirements in many countries.

2.202 The Committee notes that forecasts for nuclear capacity and uranium requirements vary, but there are a number of positive demand side trends which indicate that growth in nuclear capacity is probable:

- forecasts for a doubling in world electricity demand in the period to 2030, with a tripling of demand forecast for developing countries;
- plans for significant new nuclear build in several countries and renewed interest in nuclear energy among some industrialised nations;
- improved performance of existing nuclear power plants and operating life extensions; and
- the desire for security of fuel supplies, electricity price stability and heightened concerns about greenhouse gas emissions from the electricity sector.

2.203 In a recent development, the Committee notes the announcement by the British Government in July 2006 that, in view of the potential benefits for its public policy goals of reducing carbon dioxide emissions while delivering secure energy at affordable prices, the British Government proposes to support new nuclear build and to address potential barriers to the construction of NPPs.[208]

2.204 The Committee notes that as of June 2006 there were 27 reactors under construction in 11 countries, with a further 38 planned or on order. New plant construction is centred in the Asian region, with China, Japan and India all having plans for a significant expansion of nuclear capacity.

2.205 While new reactor construction to date has been subdued, the Committee notes that dramatic improvements in plant availability and productivity over recent years have had the effect of significantly increasing nuclear capacity and, consequently, the demand for uranium. The Committee notes that the IAEA and OECD-NEA have concluded that new nuclear build combined with the improved performance of existing NPPs and operating life extensions will outweigh reactor retirements in the years to 2025, thereby increasing projected uranium requirements.

2.206 The IAEA and OECD-NEA 'low demand' scenario forecasts that world nuclear capacity will rise to 449 GWe by 2025, which would see annual

208 UK Department of Trade and Industry, *The Energy Challenge: Energy Review Report 2006*, HM Government, London, July 2006, viewed 12 July 2006, <http://www.dtistats.net/ereview/energy_review_report.pdf>.

uranium requirement rise to 82 275 tonnes U by 2025, representing a 22 per cent increase on the 2004 requirements of 67 430 tonnes.

2.207 Uranium is unique among fuel sources in that a significant portion of demand is met by so-called secondary sources, which are essentially inventories and stockpiles. Currently, primary production from mines only supplies some 65 per cent of uranium requirements. Evidence strongly indicates that secondary supplies are diminishing, particularly with the termination of an HEU Purchase Agreement between Russia and the US in 2013. The Committee concludes that primary production must increase to meet requirements.

2.208 The Committee rejects the argument that the world's uranium resources are insufficient to support an expansion of nuclear power in the decades ahead. Total Conventional Resources are sufficient for some 270 years of nuclear electricity generation at 2004 rates of consumption. The resource base is almost certain to expand as higher uranium prices stimulate new exploration. Furthermore, additional sources of supply can eventually be utilised, including reprocessing used nuclear fuel and wider deployment of advanced reactor technologies. Fast Neutron Reactors are capable of extracting far more energy from uranium and can extend the usable fuel from known uranium resources by a factor of 60. The Committee concurs with the IAEA that there are no resource constraints on the expansion of nuclear power.[209]

2.209 Australia possesses some 36 per cent of the world's low cost uranium resources and on this basis the Committee agrees with submitters that, subject to the elimination of impediments to the industry's growth, Australia is well placed to expand production and meet global demand. Moreover, the Committee concludes that Australia is uniquely placed to supply markets in the Asian region, where nuclear growth is currently centred.

2.210 The Committee believes that it is entirely unsatisfactory for the nation, which possesses more than double the low cost uranium resources of its nearest rival, to consistently lag behind in terms of production and exports. In the following chapter the Committee examines Australia's uranium resources more closely and discusses the nation's potential to occupy a key position in world uranium supply.

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209 IAEA, *Nuclear Power's Changing Future*, Press Releases, 26 June 2004, viewed 15 June 2006, <http://www.iaea.org/NewsCenter/PressReleases/2004/prn200405.html>.

3

Australia's uranium resources, production and exploration

> *… world stockpiles of uranium are diminishing. An increase in reliance on mine production for uranium supplies by nuclear power plant operators should have the effect of increasing the significance of Australia's uranium reserves. Factors such as the size and quality of those reserves, and Australia's record as a stable and low-cost supplier, should ensure that Australia is well placed to continue to supply traditional customers and to achieve significant market penetration in Asia, which is the most rapidly growing area for use of nuclear power.*[1]

> *Without doubt Australia's known resources could be increased significantly … but there needs to be a significant change in how uranium is viewed and a clear level of support shown at both the Federal and State level. A change in political will and direction is required to give the clear message to companies that it is worthwhile exploring for uranium. Australia already plays an important role in supplying low cost uranium to support the generation of clean nuclear energy … and if properly funded and supported … the unfortunate trend of the past ten plus years can be reversed and Australia could take its rightful place as the world's most important exporter.*[2]

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1 Australian Nuclear Science and Technology Organisation (ANSTO), *Submission no. 29*, p. 5.

2 Cameco Corporation, *Submission no. 43*, p. 6.

Key messages —

- **Australia possesses 38 per cent of the world's total Identified Resources of uranium recoverable at low cost (less than US$40 per kilogram).**
- **According to company reports, Australia's known uranium deposits currently contain a total of over 2 million tonnes of uranium oxide in in-ground resources. The in-situ value of this resource at spot market prices prevailing in June 2006 is over A$270 billion.**
- **Olympic Dam in South Australia contains 26 per cent of the world's low cost uranium resources and is the world's largest uranium deposit. Olympic Dam is estimated to contain more than 1.46 million tonnes of uranium oxide in overall resources.**
- **Some 75 per cent of Australia's total Identified Resources of uranium are located in South Australia, but significant deposits are also located in the Northern Territory, Western Australia and Queensland.**
- **Seven of the world's 20 largest uranium deposits are in Australia—Olympic Dam (SA), Jabiluka (NT), Ranger (NT), Yeelirrie (WA), Valhalla (Queensland), Kintyre (WA) and Beverley (SA).**
- **Australia has the greatest diversity of economically important uranium deposit types of any country in the world, with resources of economic significance in many uranium deposit types.**
- **Despite the extent of its resources, over 10 per cent of Australia's low cost uranium resources are inaccessible, due in part to state government policies prohibiting uranium mining.**
- **In 2005, Australia achieved record national production of 11 222 tonnes of uranium oxide from three operational mines—Ranger, Olympic Dam and Beverley. Beverley is the world's largest uranium mine employing the in-situ leach (ISL) mining method.**
- **The Board of Canadian mining company sxr Uranium One has approved development of its Honeymoon deposit in SA. Honeymoon will also be an ISL operation, producing some 400 tonnes of uranium oxide per year for seven years. Production will commence from Honeymoon during 2008.**
- **A proposal to expand Olympic Dam would see uranium production from the mine treble to 15 000 tonnes of uranium oxide per year, which would make Olympic Dam and its owners, BHP Billiton Ltd, by far the world's largest producer. The expanded mine would**

account for more than 20 per cent of world uranium mine production and Australia would become the world's largest supplier of uranium with a doubling of national production.

- **Australia exported a record 12 360 tonnes of uranium oxide in 2005. This quantity of uranium was sufficient for the annual fuel requirements of more than 50 reactors (each of 1 000 megawatt electrical capacity), producing some 380 terawatt-hours of electricity in total—some one and a half times Australia's total electricity production. The value of uranium exports reached a record high of $573 million in 2005. The outlook for further increases in production and export earnings is positive.**
- **Over 80 per cent of Australia's uranium is currently supplied to customers in four countries—USA, Japan, France and the Republic of Korea.**
- **The increase in uranium price and the anticipated decline in secondary supplies have stimulated a resurgence in exploration activity and expenditure in Australia. In 2005, total exploration expenditure for uranium was $41.09 million, which was almost a three-fold increase on 2004 expenditure of $13.96 million.**
- **While there has been a trend of increasing exploration expenditure since early 2003, there has been relatively little exploration for uranium over the past two decades and Australia's known uranium resources generally reflect exploration efforts that took place 30 years ago. The size of Australia's known uranium resources significantly understates the potential resource base and there is great potential for new and significant discoveries.**
- **To assist in the discovery of new world-class uranium deposits, particularly those located at considerable depth, and to assist the junior companies which are now conducting a significant share of exploration activities, the Committee repeats key recommendations made in its last report that:**
  - ⇒ **a flow-through share scheme for companies conducting eligible minerals exploration activities in Australia be introduced; and**
  - ⇒ **Geoscience Australia be granted additional funding to develop and deploy techniques to provide precompetitive geoscience of prospective areas, in order to assist in the discovery of new world-class uranium and other mineral deposits located under cover and at depth.**

Introduction

3.1 This chapter, which is divided into three sections, provides a detailed overview of Australia's uranium resources, uranium mine production and exploration for uranium.

3.2 The Committee first considers Australia's uranium resources in world context, the distribution of uranium resources across the country, and the major uranium deposit types and their economic significance in Australia.

3.3 In the second section, the Committee summarises Australia's uranium mine production and exports performance, and provides an overview of the three currently operational mines—Ranger, Olympic Dam and Beverley. This section also describes recent developments at these mines, including the pre-feasibility study currently being undertaken for a proposed expansion of Olympic Dam. The likely development of the Honeymoon deposit in South Australia and the issue of recovering uranium from brannerite are also considered.

3.4 Finally, the Committee examines Australia's uranium exploration performance, recent exploration activity and the potential for new discoveries. The Committee concludes with a discussion of the important role now played by junior exploration companies and the importance of precompetitive geoscientific data for the discovery of new world class uranium deposits located at depth.

Resources

Resource classification schemes

3.5 Estimates of uranium resources at national and international levels are prepared in accordance with a resource classification scheme developed by the Uranium Group—a joint initiative of the OECD Nuclear Energy Agency (OECD-NEA) and the International Atomic Energy Agency (IAEA)—which collects and reports on data relating to uranium resources, production and demand. These estimates are published biennially in the OECD-NEA and IAEA publication *Uranium Resources, Production and Demand,* commonly known as the 'Red Book'. The classification scheme has been adopted internationally. Resource estimates for Australia are prepared by Geoscience Australia. Uranium resources at the level of individual deposits in Australia are reported by mining companies according to the categories of the *Australasian Code for Reporting of*

Exploration Results, Mineral Resources and Ore Reserves.[3] An explanation of these two resource classification schemes follows.

3.6 The OECD-NEA and IAEA classification scheme divides uranium resource estimates into categories that reflect the level of confidence in the quantities of recoverable uranium against the cost of production. Uranium resources are broadly classified as either conventional or unconventional. Conventional resources are those that have an established history of production where uranium is a primary product, co-product or an important by-product (e.g. from the mining of copper and gold). Very low-grade resources, or those from which uranium is only recoverable as a minor by-product, are considered unconventional resources (e.g. uranium in phosphate deposits, black shale and seawater).[4]

3.7 Conventional resources are further divided, according to the level of confidence in the occurrence of the resources, into four categories:

- Reasonably Assured Resources (RAR) refers to uranium that occurs in known mineral deposits of delineated size, grade and configuration such that the quantities which could be recovered can be specified.
- Inferred Resources refers to uranium, in addition to RAR, that is inferred to occur based on direct geological evidence, in extensions of well-explored deposits, or in deposits in which geological continuity has been established but where specific data are considered to be inadequate to classify the resources as RAR. Less reliance can be placed on the estimates in this category than in RAR.
- Prognosticated Resources refers to uranium, in addition to Inferred Resources, that is expected to occur in deposits for which the evidence is mainly indirect and which are believed to exist in well-defined geological trends or areas of mineralisation with known deposits.
- Speculative Resources refers to uranium, in addition to Prognosticated Resources, that is thought to exist, mostly on the basis of indirect evidence and geological extrapolations, in deposits discoverable with existing exploration techniques. As the name implies, the existence and size of such resources are speculative.

3.8 In this classification scheme, RAR and Inferred Resources combined are referred to as Identified Resources, while Prognosticated and Speculative Resources are referred to as Undiscovered Resources. Identified Resources are normally expressed in terms of tonnes of recoverable uranium (tU), rather than quantities contained in mineable ore (quantities in situ). That

3 Geoscience Australia, *Submission no. 42*, pp. 1, 15.

4 See: IAEA and OECD-NEA, *Uranium 2005: Resources, Production and Demand,* OECD, Paris, 2005, pp. 361–363.

is, the estimates include allowances for expected mining and ore processing losses.

3.9 Identified Resources are further separated into categories based on the cost of production, which are expressed in US dollars per kilogram of uranium (comparable cost categories in US dollars per pound of uranium oxide, U_3O_8, are included in brackets) as follows:

- less than US$40/kg U (less than US$15/lb U_3O_8);
- US$40-80/kg U (US$15-30/lb U_3O_8); and
- US$80-130/kg U (US$30-50/lb U_3O_8).[5]

3.10 The *Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves* (the 'JORC Code') has been developed by the Joint Ore Reserves Committee of the Australasian Institute of Mining and Metallurgy, Australian Institute of Geoscientists and the Minerals Council of Australia. The Code sets out minimum standards, recommendations and guidelines for public reporting in Australasia of exploration results, mineral resources and ore reserves. The Code has been adopted by and included in the listing rules of the Australian Stock Exchange.[6]

3.11 The JORC Code defines a Mineral Resource as a concentration or occurrence of material of intrinsic economic interest in or on the Earth's crust in such form, quality and quantity that there are reasonable prospects for eventual economic extraction. The location, quantity, grade, geological characteristics and continuity of a Mineral Resource are known, estimated or interpreted from specific geological evidence and knowledge. Mineral Resources are sub-divided, in order of increasing geological confidence, into Inferred, Indicated and Measured categories.[7]

3.12 The Code defines an Ore Reserve as the economically mineable part of a Measured and/or Indicated Mineral Resource. It includes diluting materials and allowances for losses, which may occur when the material is mined. Appropriate assessments and studies have been carried out, and include consideration of and modification by realistically assumed mining, metallurgical, economic, marketing, legal, environmental, social and governmental factors. These assessments demonstrate at the time of reporting that extraction could reasonably be justified. Ore Reserves are

5 *ibid.*, p. 363; Geoscience Australia, *Exhibit no. 61, Australia's uranium resources and exploration*, p. 2.

6 Joint Ore Reserves Committee of the Australasian Institute of Mining and Metallurgy, Australian Institute of Geoscientists and Minerals Council of Australia (JORC), *Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves*, JORC, 2004, p. 2.

7 *ibid.*, p. 7.

sub-divided in order of increasing confidence into Probable Ore Reserves and Proved Ore Reserves.[8]

3.13 Ore Reserves are further defined in the JORC Code as those portions of Mineral Resources which, after the application of all mining factors, result in an estimated tonnage and grade which, in the opinion of the person competent to make the estimates, can be the basis of a viable project, after taking account of all relevant modifying factors listed above.

3.14 Proved and Probable Ore Reserves plus Measured and Indicated Mineral Resources in the JORC Code are equivalent to RAR in the OECD-NEA and IAEA classification scheme. Inferred Resources in the JORC Code are equivalent to Inferred Resources in the OECD-NEA and IAEA scheme.[9]

Australia's uranium resources in world context

3.15 As at January 2005, Australia's total Identified Resources recoverable at less than US$40/kg U (i.e. recoverable at 'low-cost') amounted to 1 044 000 tU (1 230 758 t U_3O_8). This represented 38 per cent of the world's total Identified Resources in this cost category. Combined across all production cost categories, Australia's Identified Resources amounted to 1 143 000 tU.[10] Australian and world totals of Identified Resources for each cost category are listed in table 3.1.

3.16 The data in table 3.1 shows that of Australia's total Identified Resources, over 90 per cent is recoverable at low cost.[11] Furthermore, more than 67 per cent of Australia's Identified Resources recoverable at low cost are classified as RAR.

8 *ibid.*, p. 10.
9 Geoscience Australia, *Submission no. 42*, p. 15.
10 IAEA and OECD-NEA, *op. cit.*, pp. 15, 94.
11 See also: Minerals Council of Australia (MCA), *Submission no. 36*, p. 4.

Table 3.1 Australian and World Identified Resources as at January 2005

Categories of Identified Resources	**Production cost ranges**		
	Tonnes U recoverable at <US$40/kg U	Tonnes U recoverable at <US$80/kg U	Tonnes U recoverable at <US$130/kg U
Reasonably Assured Resources	701 000	714 000	747 000
Inferred Resources	343 000	360 000	396 000
Australia's total Identified Resources	1 044 000	1 074 000	1 143 000
World total Identified Resources	*2 746 380*	*2 804 381*	*4 742 853*
Australia's share of world total Identified Resources	38%	38%	24%

Source IAEA and OECD-NEA, *Uranium 2005: Resources, Production and Demand*, pp. 15–16, 102–103.

3.17 Geoscience Australia (GA) submitted that as at December 2005 Australia's RAR recoverable at low cost amounted to 716 000 tU (844 340 t U_3O_8). This represents 36 per cent of the world's uranium resources in this category.[12]

3.18 As shown in table 3.1, Australia possesses 343 000 tU in Inferred Resources recoverable at low cost, which is by far the world's largest resources in this category—43 per cent of the world total. The majority of these resources are located in the south-eastern part of the Olympic Dam deposit, where exploration drilling has defined large tonnages of additional resources.[13]

3.19 Other countries that have large quantities of RAR recoverable at low cost include Canada (15 per cent of the world total), Kazakhstan (14 per cent), Niger (9 per cent), Brazil (7 per cent), South Africa (5 per cent), Uzbekistan (4 per cent), Namibia (3 per cent) and the Russian Federation (3 per cent).[14] Table 3.2 and figure 3.1 show the distribution of RAR among countries with major resources.

12 Information provided by Mr Aden McKay (GA), 21 June 2006. This figure includes resource estimates contained in Summit Resources' submission to the Committee's inquiry, that the company's Mount Isa uranium project contains a resource of over 34 500 t U_3O_8 recoverable at low cost. See: Summit Resources Ltd, *Submission no. 15*, p. 12; Mr Alan Eggers (Summit Resources Ltd), *Transcript of Evidence*, 3 November 2005, pp. 4, 5.

13 GA, *Exhibit no. 61*, *op. cit.*, p. 5.

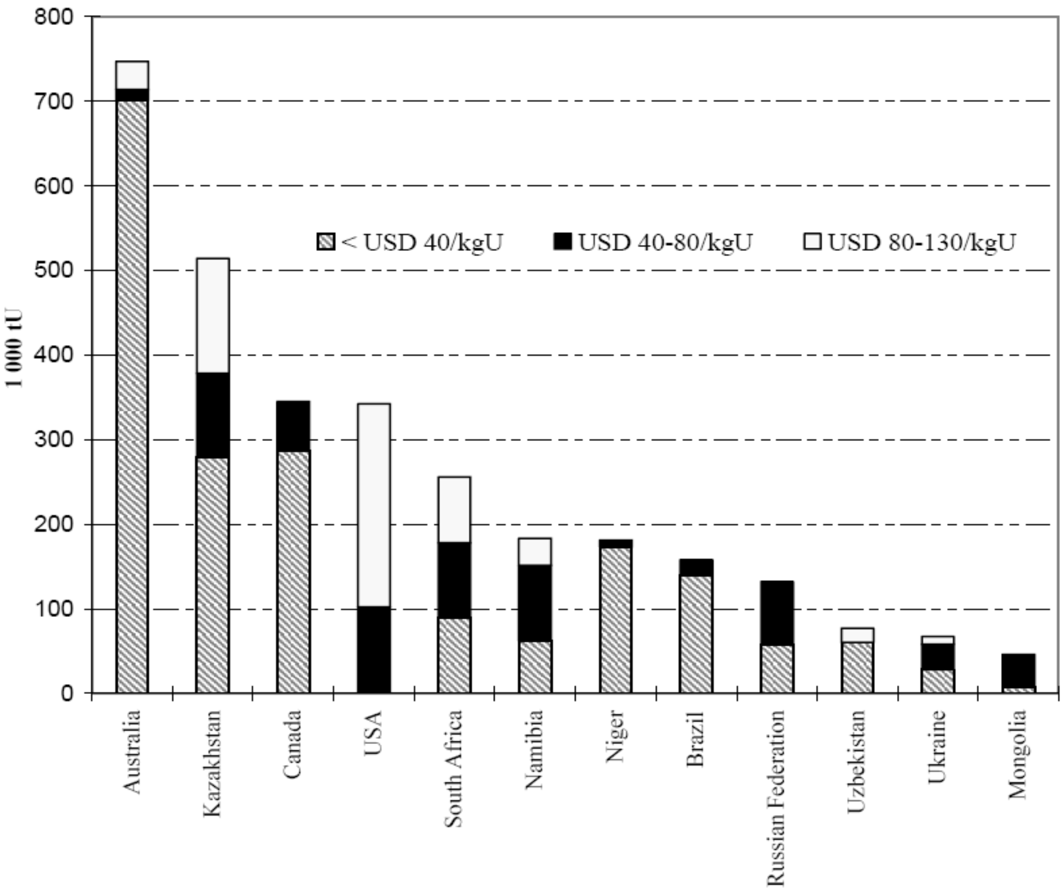
14 IAEA and OECD-NEA, *op. cit.*, p. 15; Areva, *Submission no. 39*, p. 13.

Table 3.2 Reasonably Assured Resources (tU) as at January 2005

Country	Production cost ranges		
	<US$40/kg U	US$40–80/kg U	US$80–130/kg U
Australia	701 000	13 000	33 000
Brazil	139 900	17 800	0
Canada	287 200	58 000	0
Kazakhstan	278 840	99 450	135 607
Mongolia	7 950	38 250	0
Namibia	62 186	89 135	31 235
Niger	172 866	7 580	0
Russian Federation	57 530	74 220	0
South Africa	88 548	88 599	78 446
Ukraine	28 005	30 493	8 208
United States	NA	102 000	240 000
Uzbekistan	59 743	0	17 193
Others	*63 615*	*77 433*	*209 657*
World total	1 947 383	695 960	653 346

Source IAEA and OECD-NEA, *Uranium 2005: Resources, Production and Demand*, p. 15.

Figure 3.1 Distribution of Reasonably Assured Resources among countries with major resources



Source IAEA and OECD-NEA, *Uranium 2005: Resources, Production and Demand*, p. 18.

Distribution of uranium resources in Australia

3.20 Approximately 98 per cent of Australia's Identified Resources recoverable at less than US$40/kg U are contained within the following six deposits:

- Olympic Dam in South Australia (SA);
- Ranger, Jabiluka and Koongarra in the Alligator Rivers Region Uranium Field (ARUF) of the Northern Territory (NT); and
- Kintyre and Yeelirrie in Western Australia (WA).[15]

3.21 Australia has some 85 known uranium deposits, varying in size from small to very large, scattered across the continent. Approximately 75 per cent of Australia's total Identified Resources recoverable at low cost are located in South Australia (782 798 tU or 923 111 t U_3O_8), 19 per cent is located in the Northern Territory (193 818 tU or 228 559 t U_3O_8) and 6 per cent in Western Australia (67 067 tU or 79 088 t U_3O_8).[16]

3.22 Olympic Dam is the world's largest deposit of low cost uranium. Based on ore reserves and mineral resources reported by the mine's owners as at June 2005, GA estimated that Olympic Dam contains 503 300 tU in RAR recoverable at less than US$40/kg U. This represents 26 per cent of the world's total resources and over 70 per cent of Australia's resources in this category.[17] Olympic Dam is estimated to contain in excess of 1.46 million t U_3O_8 (1.27 million tU) in total resources.[18] Moreover, of the world's 20 largest uranium deposits, seven are in Australia—Olympic Dam, Jabiluka, Ranger, Yeelirrie, Valhalla (Queensland), Kintyre and Beverley (SA).[19]

3.23 The location of Australia's uranium deposits and the relative size of ore reserves and mineral resources for each deposit are depicted in figure 3.2. Australia's major undeveloped uranium deposits, prospective mines and their main owners are listed in table 3.3.[20]

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15 IAEA and OECD-NEA, *op. cit.*, p. 95; GA, *Submission no. 42*, p. 15; MCA, *loc. cit.*

16 GA, *Exhibit no. 61, op. cit.*, p. 3. As noted above, Summit Resources submitted that the company's Mount Isa uranium project in Queensland contains Identified Resources of 35 000 t U_3O_8 recoverable at low cost. See also: I Lambert et. al., *Why Australia has so much uranium*, GA, Canberra, 2005, viewed 4 July 2006, <http://www.ga.gov.au/image_cache/GA7518.pdf>.

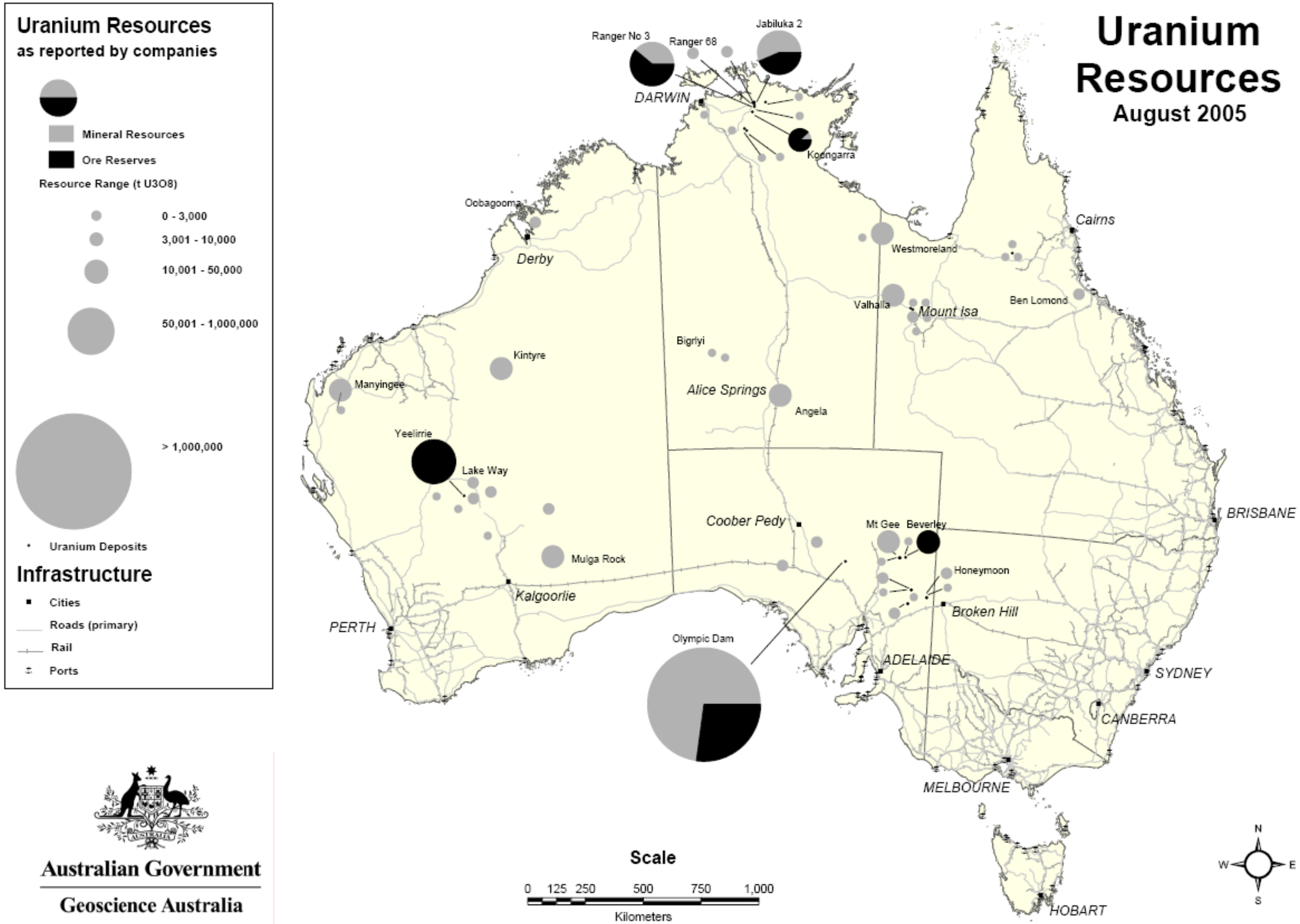
17 Information provided by Mr Aden McKay (GA), 21 June 2006.

18 Dr Roger Higgins (BHP Billiton Ltd), *Transcript of Evidence*, 2 November 2005, p. 3. See also: Uranium Information Centre (UIC), *Australia's Uranium Mines*, viewed 21 June 2006, <http://www.uic.com.au/emine.htm>.

19 Mr Stephen Mann (Areva), *Transcript of Evidence*, 23 September 2005, p. 2.

20 Detailed information including the historical background of each deposit is available online from the UIC, *Australia's Uranium Deposits and Prospective Mines*, viewed 20 June 2006, <http://www.uic.com.au/pmine.htm>.

Figure 3.2 Location of Australia's uranium deposits and the relative size of ore reserves and mineral resources for each deposit



Source Geoscience Australia, *Exhibit no. 61, Australia's uranium resources and exploration.*

Table 3.3 Australia's major undeveloped uranium deposits and prospective mines as at April 2006

State / Territory	Deposit	Main owner	Grade (per cent U_3O_8)	Contained U_3O_8 (tonnes)	Category
Northern Territory	Jabiluka	Energy Resources of Australia Ltd (Rio Tinto 68%)	0.52	67 000	reserves
			0.39	21 000	measured and indicated resources
			0.48	75 000	inferred resources
	Koongarra	Areva	0.8	14 540	reserves
	Angela	Cameco	0.1	10 250	resources
Western Australia	Kintyre	Canning Resources Pty Ltd (Rio Tinto)	0.15 – 0.4	36 000	reserves and resources
	Yeelirrie	BHP Billiton Ltd	0.15	52 500	indicated resources
	Mulga Rock	Eaglefield Holdings Pty Ltd	0.14	13 300	resources
	Manyingee	Paladin Resources Ltd	0.09	12 000	resources
	Oobagooma		not known	5 000	resources
	Lake Maitland	Redport Ltd	0.052	7 900	resources
	Lake Way	Nova Energy Ltd	not known	4 000	resources
	Centipede		0.063	4 400	resources
	Thatchers Soak	Uranex NL	0.03	4 100	resources
South Australia	Honeymoon	sxr Uranium One Inc	0.24	2 900	resources
	Goulds Dam		0.045	2 500	indicated resources
	Curnamona	Curnamona Energy Ltd	not known	Not known	-
	Prominent Hill	Oxiana Ltd	0.012	9 900	inferred resources
	Mt Gee	Marathon Resources Ltd	0.073	33 200	inferred resources
	Crocker Well	PepinNini Minerals Ltd	0.51	6 338	resources
Queensland	Westmoreland (Qld/NT)	Laramide Resources Ltd	up to 0.2	22 500	inferred resources
	Valhalla	Summit Resources Ltd	0.144	16 500	indicated resources
				25 000	inferred resources
	Skal		0.119	5 000	resources
	Andersons Lode		0.143	6 500	inferred resources
	Ben Lomond	Mega Uranium Ltd	0.25	4 760	resources
	Maureen		0.123	2 940	resources

Source UIC, *Submission no. 12*, p. 24; UIC, *Australia's Uranium Deposits and Prospective Mines*.

3.24 In addition to the currently operational mines described below, GA submitted that several uranium deposits have in previous years been subject to either a comprehensive feasibility study or an Environmental Impact Statement (EIS), or both. These projects have not proceeded to mining for a variety of reasons including state government mining restrictions or previously low uranium prices. These deposits are: Jabiluka and Koongarra in the NT; Kintyre, Yeelirrie, Manyingee and Lake Way in WA; and Ben Lomond and Valhalla in Qld.[21]

3.25 Several of the junior mining and exploration companies that submitted to the inquiry made observations about the resources contained in their uranium deposits:

- Summit Resources submitted that the company's Mount Isa uranium project (the Valhalla, Skal and Andersons Lode deposits) in Queensland (Qld) contains a total uranium resource (RAR and Inferred) of over 34 500 t U_3O_8 (29 255 tU) recoverable at low cost.[22] GA have now incorporated these resources into the estimates for Australia's RAR recoverable at low cost, provided above.
- Eaglefield Holdings, owners of the Mulga Rock deposit (MRD) in WA, noted that the MRD was evaluated by the deposit's previous owner to contain an estimated 46 000 t U_3O_8 (33 918 tU). However, the age of the resource estimation renders it non-JORC compliant. In addition to its uranium content, Eaglefield Holdings submitted that the MRD may also contain the largest known exploitable resource of scandium in the world, as well as a very large resource of oily-lignite.[23]
- Nova Energy noted that, combined, its Lake Way and Centipede/Millipede deposits in WA contain an estimated 8 860 t U_3O_8 (7 513 tU).[24]
- Compass Resources announced in July 2006 that its Mt Fitch uranium prospect in the NT contains an estimated 4 050 t U_3O_8 (3 434 tU) in indicated and inferred resources.[25]

3.26 Just over 10 per cent of Australia's RAR recoverable at less than US$40/kg U has been classified by GA as inaccessible for mining. This is

21 GA, *Exhibit no. 61, op. cit.*, p. 5.

22 Summit Resources Ltd, *op. cit.*, pp. 12, 14.

23 Eaglefield Holdings Pty Ltd, *Submission no. 18*, p. 1. It was explained that scandium is a highly sought after commodity for the manufacture of aluminium alloys in the aerospace industry. See: Mr Michael Fewster (Eaglefield Holdings Pty Ltd), *Transcript of Evidence*, 23 September 2005, pp. 24–27.

24 Nova Energy Ltd, *Submission no. 50*, p. 12.

25 Compass Resources NL, *Uranium Resources Delineated at Mt Fitch Prospect*, viewed 19 July 2006, <http://www.compassnl.com.au/news_room/_announcements/2006_CMR_Uranium_Resource_Delineated.pdf>.

due in part to prohibitions on mining in WA. WA State Government policy prohibits uranium mining on leases granted after June 2002, hence deposits in that State are classified as 'inaccessible resources'. The MCA submitted that current WA Government policy prevents Kintyre and Yeelirrie from being developed. The Qld State Government has also discouraged potential new mine developments, despite the absence of legislation that specifically prohibits uranium mining.[26]

3.27 Inaccessible resources also includes those deposits in the ARUF where mining leases are too small to accommodate the proposed mine and treatment plant facilities, such as Koongarra. These leases may not be able to be increased in size as they are surrounded by the Kakadu National Park. However, the MCA noted that the leases for both Jabiluka and Koongarra predate and were excluded from the Kakadu National Park.[27]

3.28 According to company reports, Australia's uranium deposits contain a total of over two million t U_3O_8.[28] The in-situ value of this resource at uranium spot market prices prevailing in June 2006 is over A$270 billion.[29] The uranium ore reserves and mineral resources for each of Australia's uranium deposits, as reported by the mining companies, are listed in appendix E by state and territory.

3.29 Notwithstanding the size of Australia's known uranium resources, submitters argued that these underestimate the potential uranium resource base because, until recently, there has been very little exploration activity in Australia for more than 20 years.[30] This matter is considered in the final section of this chapter.

Uranium deposit types and their economic significance in Australia

3.30 The OECD-NEA and IAEA have classified uranium deposits worldwide into fifteen deposit types on the basis of their geological setting.[31] GA explained that 98 per cent of Australia's uranium resources occur within four such deposit types:

- Hematite breccia complex deposits—deposits of this type occur in hematite-rich breccias and contain uranium in association with copper, gold, silver and rare earths.

26 GA, *Exhibit no. 62, Australia's Identified Mineral Resources*, p. 4; GA, *Submission no. 42*, pp. 17–18.

27 MCA, *op. cit.*, p. 5.

28 GA, *Exhibit no. 61, op. cit.*, p. 15.

29 Calculated on the basis of the uranium spot market price of US$45/lb U_3O_8 and 1A$ = 0.73US¢.

30 MCA, *op. cit.*, p. 4.

31 OECD-NEA and IAEA, *Uranium 2005: Resources, Production and Demand*, *op. cit.*, pp. 368–372.

Some 70 per cent of Australia's total uranium resources occur in Proterozoic hematite-rich granitic breccias at Olympic Dam, which is also the only known breccia complex that has a significant resource of uranium in the world. Broadly similar, but apparently smaller, hematite-rich breccia mineralisation is being evaluated elsewhere in the same geological province (the Gawler Craton), at Prominent Hill in South Australia. These are examples of 'iron oxide copper gold deposits' with higher uranium contents than most deposits of this type.

- Unconformity-related deposits—deposits of this type are associated with and occur immediately below and above an unconformable contact that separates a crystalline basement intensively altered from overlying clastic sediments of either Proterozoic or Phanerozoic age.

  About 18 per cent of Australia's resources are associated with Proterozoic unconformities, mainly in the ARUF of the NT (Ranger, Jabiluka, Koongarra).

- Sandstone uranium deposits—deposits of this type occur in medium to coarse-grained sandstones in a continental fluvial or marginal marine sedimentary environment.

  Some six per cent of Australia's resources are sandstone uranium deposits and are located mainly in the Frome Embayment field, SA (Beverley, Honeymoon) and the Westmoreland area, which straddles the NT and Qld.

- Surficial (calcrete) deposits—deposits of this type are broadly defined as young (Tertiary to recent) near-surface uranium concentrations in sediments and soils.

  These deposits constitute about four per cent of Australia's uranium resources, mostly in the Yeelirrie deposit (WA).[32]

3.31 Cameco noted that other deposit types are found in Australia, such as metasomatite type deposits including Valhalla in Qld, where disseminated uranium is deposited in deformed rocks. Intrusive type deposits such as Maureen and Ben Lomond are found within the Georgetown Inlier in Northwest Qld and the Westmoreland area hosts a number of vein and other sandstone deposits.[33]

3.32 The Northern Territory Minerals Council (NTMC) noted that uranium occurrences in the NT can be grouped into unconformity-related, vein-like, Westmoreland and sandstone type deposits. Almost all mined deposits and most of the currently known resources are unconformity-related and occur within Palaeoproterozoic rocks of the Pine Creek

32 GA, *Submission no. 42*, p. 17.

33 Cameco Corporation, *Submission no. 43*, p. 6.

Orogen, near the unconformity with overlying platform cover sandstone of the McArthur Basin or Birrindudu Basin. The NTMC noted that large unconformity deposits in the ARUF account for 96 per cent of past production and 95 per cent of known resources in the Territory. Smaller Westmoreland-type deposits (e.g. Eva) are present in the eastern McArthur Basin. Sandstone-hosted deposits are present in the Ngalia (e.g. Bigrlyi) and Amadeus (e.g. Angela) basins. Small vein-type deposits in the Pine Creek Orogen (e.g. Adelaide River) have been mined in the past.[34] The location of the known uranium deposits in the NT and their geological settings are depicted in appendix F.

3.33 Dr Donald Perkin submitted that 'world class' deposits are those that contain high-grade uranium ore, coupled with large tonnages and/or features which reduce the cost of mining such as convenient shape, well defined ore zones, easily treatable ore and good location. Because world class deposits are lowest cost, they are the most competitive and least vulnerable to downturns in the industry.[35]

3.34 Dr Perkin argued that 'Australia is unique in having the greatest diversity of economically important uranium deposit types of any country in the world', with resources of economic significance in many uranium deposit types.[36]

3.35 It was argued that the unconformity-related and sandstone deposit types:

> … represent potentially viable uranium mining operations and exploration target types into the future, and with their relatively high grades and large resources, these types will easily be able to withstand … erosion in real price and, in a more positive market, able to provide strong future cash flows and profits.[37]

3.36 Consequently, Dr Perkin argued that Australia along with Canada and Niger, which have a predominance of the world's relatively high-grade resources in these deposit types, are therefore 'uniquely suited to become chief suppliers of low-cost uranium to the world nuclear power industry well into the 21st century.'[38]

Thorium

3.37 In addition to uranium resources, Australia also possesses the world's largest quantity of economically recoverable thorium resources—

34 NTMC, *Submission no. 51*, p. 5.

35 Dr Donald Perkin, *Exhibit no. 3, The Significance of uranium deposits through time*, pp. 93, 108.

36 *ibid.*, p. 70.

37 *ibid.*, p. 114.

38 *ibid.*

300 000 t—more than Canada and the US combined, as shown in table 3.4. The 2005 Red Book states that current estimates put world thorium resources at 4.5 million tonnes (Mt), but this figure is considered conservative.[39]

Table 3.4 World's economically extractable thorium resources

Country	Reserves (tonnes)
Australia	300 000
India	290 000
Norway	170 000
USA	160 000
Canada	100 000
South Africa	35 000
Brazil	16 000
Other countries	95 000
World total	1 200 000

Source UIC, *Thorium*, Briefing Paper No. 67.

3.38 Like uranium, thorium can be used as a nuclear fuel. Interest in utilising thorium has arisen because it is three times more abundant in the Earth's crust than uranium, and almost all of the mined thorium is potentially usable in a reactor, compared with only 0.7 per cent of natural uranium. Thus, thorium may contain some 40 times the amount of energy per unit mass than uranium, without recourse to fast breeder reactors.[40] Thorium-based fission is described further in chapter 12.

3.39 India, which has about six times more thorium than uranium, is currently building two reactors which will use thorium-based fuel and has made the utilisation of thorium for large-scale energy production a major goal in its nuclear power program. While thorium has been the subject of research for several decades, the thorium fuel cycle is not yet commercialised.[41]

3.40 Arafura Resources submitted that the company's Nolan's Bore deposit, located 135 km north of Alice Springs, contains both thorium and uranium hosted in phosphate rock. Recent drilling indicates that the deposit contains some 24 000 t of thorium, as well as 1 800 tU and 227 000 t of rare earths.[42]

39 IAEA and OECD-NEA, *op. cit.*, p. 21.

40 UIC, *Thorium*, Briefing Paper No. 67, June 2006, viewed 3 July 2006, <http://www.uic.com.au/nip67.htm>; Professor Igor Bray, *Transcript of Evidence*, 2 March 2006, p 4.

41 UIC, *Thorium, loc. cit.*; Professor Igor Bray, *loc. cit.*

42 Mr Alistair Stephens (Arafura Resources NL), *Transcript of Evidence*, 23 September 2005, p. 47.

Production and exports

Australia's uranium mine production and exports

3.41 Australia's uranium production in 2005 came from three mines: Ranger (5 910 t U_3O_8), Olympic Dam (4 335 t U_3O_8) and Beverley (977 t U_3O_8). Combined, the mines achieved record national production of 11 222 t U_3O_8, six per cent higher than in 2004. As noted in the previous chapter, Australia is the world's second largest producer of uranium, accounting for 23 per cent of world uranium mine output in 2005, after Canada (28 per cent).[43]

3.42 All of Australia's uranium mine production is exported for use in electrical power generation. Australian export tonnages have increased steadily from less than 500 t U_3O_8 in 1976, to reach a record level of 12 360 t U_3O_8 in 2005. Exports for 2005 were valued at A$573 million—a record for annual export earnings. In the five years to 2006, Australia exported 48 496 t U_3O_8 with a value of $2.2 billion. The average export value in 2005 was $46 360 per tonne of U_3O_8.[44] Table 3.5 shows Australia's uranium mine production and exports for 2000 to 2005.

3.43 The Australian Bureau of Agricultural and Resource Economics (ABARE) has forecast that Australian uranium mine production will grow by over eight per cent in financial year 2005–06 to nearly 11 900 t U_3O_8, largely due to higher output from Olympic Dam and Ranger. The value of uranium exports is forecast to reach A$712 million in 2005–06, an increase of 50 per cent on the 2004–05 export value of $475 million.[45]

3.44 Uranium produced in Australia is shipped to uranium conversion plants in France, USA, Canada and the UK. Following the other steps of the 'front end' of the fuel cycle, outlined in chapter two, Australian uranium is used to fabricate fuel elements for use in nuclear power stations.[46]

43 RWE NUKEM, *NUKEM Market Report*, May 2006 edition, RWE NUKEM Inc, Danbury, Connecticut, May 2006, p. 17; GA, *Exhibit no. 62, op. cit.*, p. 5; UIC, *Newsletter*, Issue No. 2, March/April 2006.

44 GA, *Submission no. 42*, p. 10; UIC, *Submission no. 12*, p. 27.

45 ABARE, *Australian Commodities*, Vol. 13, No. 1, March Quarter 2006, Commonwealth of Australia, Canberra, 2006, p. 107, viewed 23 June 2006, <http://www.abareconomics.com/publications_html/ac/ac_06/ac06_march.pdf>.

46 GA, *Submission no. 42*, p. 10.

Table 3.5 Australian uranium mine production and exports (tonnes U_3O_8), 2000–2005

	2000	2001	2002	2003	2004	2005
Ranger	4 437	4 203	4 407	5 065	5138	5 910
Percentage of world production	10%	10%	11%	12%	11%	12%
Olympic Dam	4 500	4 335	2 867	3 176	4 370	4 335
Percentage of world production	11%	10%	7%	7%	9%	9%
Beverley	—	546	746	689	1 084	977
Percentage of world production		1%	2%	2%	2%	2%
Australian total	8 937	9 104	8 083	8 931	10 592	11 222
Percentage of world production	21%	21%	20%	21%	22%	23%^
World mine production	42 466	43 656	42 502	42 184	47 955^	49 375^
Australian exports	8 757	9 239	7 637	9 612	9 648	12 360
Value of Australian exports* (A$ million)	426	463	363	398	411	573
Average export value in A$/lb U_3O_8	22.07	22.72	21.58	18.78	19.32	21.03
Average export value in US$/lb U_3O_8	12.85	11.78	11.73	12.24	14.22	16.03

Source UIC, *Submission no. 12*, p. 27; GA, *Submission no. 42*, p. 7; UIC, *Australia's Uranium and Who Buys It*, Nuclear Issues Briefing Paper No. 1.
* Export values are free-on-board estimates.
^ Figures obtained from RWE NUKEM, *NUKEM Market Report*, May 2006, p. 14.

3.45 Australian mining companies supply uranium under long-term contract to electricity utilities in the following countries: USA, Japan, European Union (UK, France, Germany, Spain, Sweden, Belgium, Finland), South Korea, Canada and to Taiwan under safeguards agreements with the USA.[47] In 2004, Australian uranium was supplied to customers in the countries listed in table 3.6.

3.46 In April 2006, Australia and China entered into a bilateral safeguards agreement on the transfer of nuclear material, whereby sales of uranium to China will now be permitted.[48]

47 *ibid.*, p. 11; Dr Clarence Hardy (Australian Nuclear Association), *Transcript of Evidence*, 16 September 2005, p. 51.

48 Australian Safeguards and Non-Proliferation Office (ASNO), *Agreement Between the Government of Australia and The Government of the People's Republic of China on the Transfer of Nuclear Material*, viewed 26 June 2006, <http://www.dfat.gov.au/geo/china/treaties/nuclear_material.html>.

Table 3.6 Supplies of Australian uranium shown by end-user, 2004

Country	Tonnes U_3O_8	% of total
United States	3 513.89	38.4
Japan	2 292.49	25.0
France	939.06	10.3
Republic of Korea	930.00	10.1
Sweden	400.95	4.4
United Kingdom	382.84	4.2
Germany	249.48	2.7
Spain	200.00	2.2
Canada	136.08	1.5
Finland	112.03	1.2
TOTAL	**9 156.82***	**100.0**

Source Australian Safeguards and Non-Proliferation Office, *Annual Report 2004–2005*, p. 45.
* Total quantity supplied does not equal total exports (9 648 t U_3O_8) during 2004 due to timing differences in the reporting of exports and receipts.

3.47 Uranium produced from Australia's mines is largely sold under long-term contracts and thus the spot market price for uranium is not indicative of the price paid for current production. The spot market price is currently well above the long-term contract price. For example, in 2005 the average realised sale price of U_3O_8 sold by Energy Resources of Australia from its Ranger mine was US$16/lb, whereas the spot market price on 31 December 2005 was more than double this at US$36/lb U_3O_8.[49] In June 2006 the spot price reached US$45/lb U_3O_8.[50] Similarly, BHP Billiton reported that the contract price for uranium produced at Olympic Dam is currently approximately US$15/lb.[51]

3.48 In financial year 2004–05, Australia exported 11 215 t U_3O_8, in 64 shipments from the three operational mines. This quantity of uranium was sufficient for the annual fuel requirements of approximately 50 reactors (each of 1 000 MWe capacity), producing some 380 TWh of electricity in total—some one and a half times Australia's total electricity production. Effectively, Australian uranium supplied about 2 per cent of total world electricity production in 2004–05.[52]

49 Energy Resources of Australia Ltd (ERA), *Full Year Results 2005*, Media Release and Stock Exchange Announcement, issued 1 February 2006, viewed 21 April 2006, <http://www.energyres.com.au/showpdf.php3?id=212>.

50 Spot price for uranium oxide obtained from <http://www.uxc.com/>.

51 Dr Roger Higgins (BHP Billiton Ltd), *Transcript of Evidence*, 2 November 2005, p.5.

52 ASNO, *Annual Report 2004–2005*, Commonwealth of Australia, Canberra, 2005, p. 23.

3.49 As noted above, Australia currently has three operational uranium mines—Ranger in the NT, and Olympic Dam and Beverley in SA. The locations of these mines are shown in figure 3.2.

3.50 In 2005, the Ranger and Olympic Dam mines were respectively the world's second largest (12 per cent of world uranium mine production) and third largest (9 per cent of world mine production) uranium producers (see table 2.4 of chapter two). Beverley was the tenth largest producer in 2005.[53] In addition to the operational mines, a fourth—Honeymoon in SA—has government approvals in place to commence construction and in August 2006 the deposit's owners approved development of the project.[54] Following a brief overview of the history of uranium mining in Australia, the Committee describes the three currently operational mines.

Australia's uranium mining history

3.51 Uranium was first identified in Australia in 1894 at Carcoar (NSW). The earliest uranium deposits mined in Australia were at Radium Hill and Mount Painter (SA). These deposits were worked from 1910 to 1931 for radium, a radioactive daughter product of uranium, which was used mainly for medical purposes.

3.52 Exploration for uranium in Australia began in 1944 at the request of the British and US Governments. The Commonwealth Government offered financial rewards for the discovery of uranium orebodies and in 1949 the Rum Jungle deposit (NT) was discovered. Subsequently, the Mary Kathleen deposit (Qld) and a number of smaller deposits in the South Alligator Valley (NT) were discovered.[55]

3.53 There have been two phases of uranium mining in Australia:

- from 1954 until 1971; and
- from 1976 to the present.[56]

3.54 Between 1954 and 1971 the following deposits were mined: Rum Jungle (1954 to 1971), Radium Hill (1954 to 1962), Mary Kathleen (1958 to 1963) and South Alligator Valley (1959 to 1964). During this phase, Australia produced some 9 118 t U_3O_8 (7 732 tU) and sales were to the USA and UK

53 *ibid.*

54 MCA, *op. cit.*, p. 5.

55 See: UIC, *Australia's Uranium and Who Buys It*, viewed 27 June 2006, <http://www.uic.com.au/nip01.htm>.

56 The historical overview is extracted from: AD McKay and Y Miezitis, *Australia's Uranium: Resources, Geology and Development of Deposits*, GA, Canberra, 2001, pp. 10–18. See also: UIC, *Submission no. 12*, p. 23.

for use in weapons programs. The first phase of uranium production in Australia ceased after the closure of the Rum Jungle plant in 1971.

3.55 Uranium exploration declined during the late 1950s but increased again in the late 1960s, stimulated by the easing of a Commonwealth Government export embargo and predictions of increased world demand for uranium in the early 1970s for generating nuclear power.

3.56 Important deposits were discovered between 1969 and 1973 at Nabarlek, Ranger, Koongarra and Jabiluka in the Alligator Rivers area, at Beverley and Honeymoon in the Lake Frome area (SA), and at Yeelirrie and Lake Way (WA). The Olympic Dam and Kintyre deposits were discovered in 1975 and 1985 respectively.

3.57 Mary Kathleen began recommissioning its mine and mill in 1974. Consideration by the Commonwealth Government of additional sales contracts was deferred pending the findings of the Ranger Uranium Environmental Inquiry which commenced in 1975. In 1977 the Commonwealth announced that new uranium mining could proceed, commencing with the Ranger project in the Northern Territory. The Ranger mine opened in 1981.

3.58 Australia's second phase of uranium mining commenced in 1976, with the resumption of mining at Mary Kathleen, and continues to the present. In addition to Mary Kathleen, mining has been from the Nabarlek, Ranger, Olympic Dam and Beverley operations.

3.59 Mary Kathleen ceased production in 1982 and 4 802 t U_3O_8 (4 072 tU) was produced from the mine during its second period of operation. The Nabarlek deposit was mined and stockpiled in 1979. The stockpiled ore was then processed from 1980 to mid-1988 for a total output of 10 858 U_3O_8 (9 208 tU), which was sold to Japan, Finland and France.

3.60 Since the start of Australia's second phase of uranium mining in 1976, cumulative uranium production to the end of 2005 has been 146 315 t U_3O_8 (124 068 t U). This includes production from Mary Kathleen, Nabarlek, Ranger (1981 to the present), Olympic Dam (1988 to the present), and from Beverley (2001 to the present).

3.61 Having won Government in 1983, the Australian Labor Party's 1984 National Conference amended the Party's Platform to what has become known as the 'three mines policy', nominating Ranger, Nabarlek and Olympic Dam as the only projects from which exports would be permitted. Provisional approvals for marketing from other prospective uranium mines were cancelled. This policy prevailed until the election of the Coalition Government in 1996.

3.62 The following section of this chapter describes Australia's three currently operational uranium mines and associated recent developments.

Ranger

3.63 The Ranger uranium deposit, which is located 230 km east of Darwin in the Alligator Rivers region (see figure 3.2 and appendix F), was discovered in 1969 by a joint venture of Peko Wallsend and The Electrolytic Zinc Company of Australia. Development of the Ranger mine was the subject of the Ranger Uranium Environmental Inquiry, a major Commonwealth Government inquiry under Justice RW Fox between 1975 and 1977. The findings of the inquiry allowed the development of both the Ranger and Nabarlek mines. In 1978 the Commonwealth Government and the Northern Land Council, acting on behalf of the Traditional Aboriginal land Owners, reached agreement to proceed with mining, which commenced in 1979.[57]

3.64 The Ranger Project Area and the adjoining Jabiluka Mineral Lease are surrounded by, but not part of, the Kakadu National Park. Both areas are located on Aboriginal land, under title granted to the Traditional Owners, the Mirrar Gundjeihmi people, under the *Aboriginal Land Rights Act (NT) 1976*.[58] Ranger is served by the township of Jabiru, which was constructed largely for the purpose.

3.65 Ranger is a large unconformity-related deposit and the ore is mined by open cut methods. As depicted in figure 3.3, within the Ranger Project Area there are two orebodies—Ranger No. 1 (now mined out) and Ranger No. 3 which is currently being mined. Open cut mining at the Ranger No. 1 orebody began in August 1981 and was completed by December 1994. Production from the processing plant continued from stockpiled ore until open cut mining commenced at Ranger No. 3 orebody in October 1996.

3.66 The Ranger mill has a nominal production capacity of 5 000 t U_3O_8 per year (4 240 tU), however production has exceeded this in recent years. Approximately 2.1 Mt of ore are milled annually (a record 2.3 Mt in 2005). Uranium recovery from the processed ore is about 91.5 per cent and ranges up to 93 per cent.[59] The mill uses a sulphuric acid leach process to dissolve uranium from the ore. Uranium is recovered from the leachate by solvent extraction and is precipitated as ammonium diuranate (yellowcake). This is then calcined (heated to more than 200°C to remove volatile components) to produce concentrates of uranium oxide (grey-green coloured powder) assaying 99.2 per cent U_3O_8.[60]

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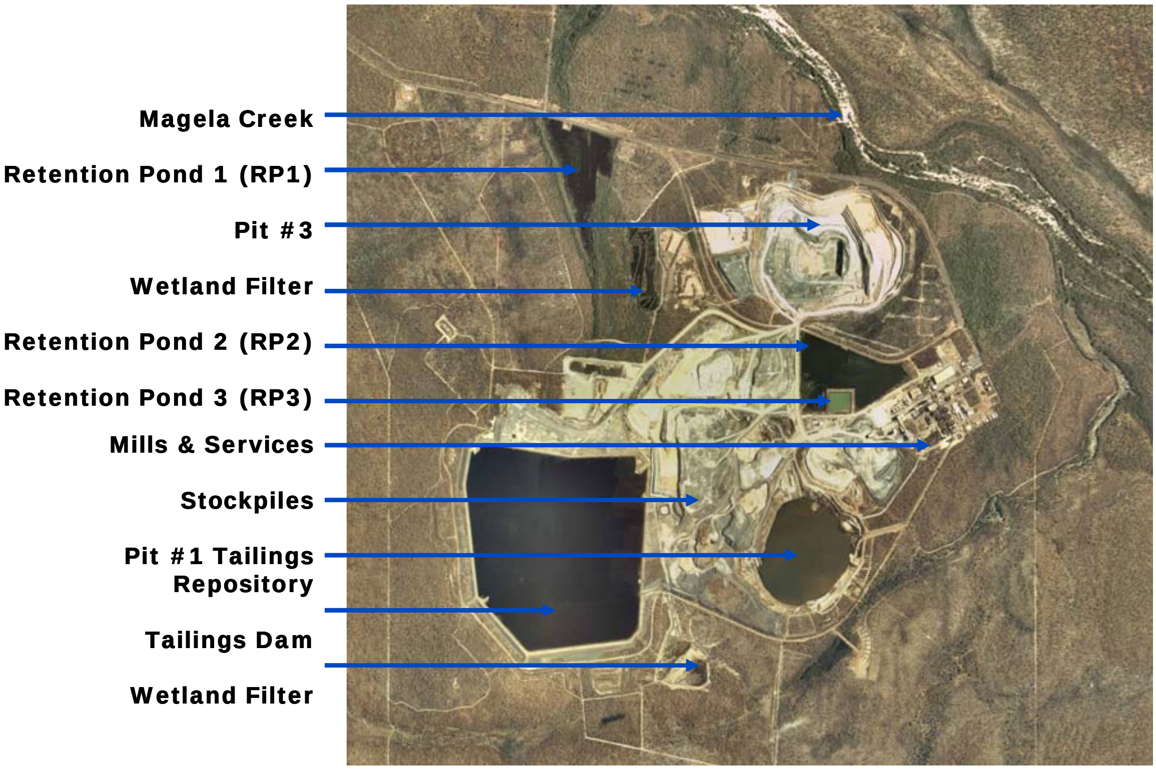
57 UIC, *Australia's Uranium Mines, loc. cit.*; ERA, *Exhibit no. 76, What is it really like to operate a large uranium mine in Australia?*, pp. 2-4; McKay and Miezitis, *op. cit.*, p. 13.

58 GA, *Submission no. 42*, p. 8.

59 UIC, *Australia's Uranium Mines, loc. cit.*

60 GA, *Submission no. 42*, p. 9.

Figure 3.3 Ranger mine site



Source Energy Resources of Australia.

3.67 Since August 1997, the No. 1 orebody open cut (Pit 1) has been used as a repository for mill tailings. The company proposes to finally dispose of all mill tailings into the No. 1 and No. 3 orebody open cuts, on completion of mining.[61]

3.68 Production from Ranger was a record 5 910 t U_3O_8 (5 012 tU) in 2005, 15 per cent above production levels for 2004.[62] In 2005, production from Ranger amounted to 12 per cent of the world total and was the world's second largest uranium mine (in terms of annual production), behind the very high grade McArthur River mine in Saskatchewan (Canada) which produced 8 491 t U_3O_8.[63] Uranium mined from Ranger is sold to utilities in Japan, South Korea, Europe (France, Spain, Sweden and the UK) and North America.[64] In 2005, the Ranger mine employed more than 350 people, including 46 Indigenous people.[65]

3.69 Ranger is now owned by Energy Resources of Australia (ERA), a subsidiary of Rio Tinto (which owns 68 per cent of ERA). In 2005, Rio

61 *ibid*.

62 ERA, *Full Year Results 2005, loc. cit.*

63 GA, *Submission no. 42*, p. 9; RWE NUKEM, *NUKEM Market Report*, *loc. cit.*

64 Mr Harry Kenyon-Slaney (ERA), *Transcript of Evidence*, 24 October 2005, p. 46.

65 ERA, *2005 Annual Report*, pp. 12, 18, viewed 27 June 2006, <http://www.energyres.com.au/corporate/era-ar-2005.pdf>.

Tinto was the world's second largest producer of uranium after Cameco (Canada), with Areva (France) the third largest producer.[66]

3.70 At the end of 2005, Ranger contained total Proved and Probable Reserves of 44 458 t U_3O_8 and an additional 42 587 t U_3O_8 in mineral resources (total of Measured, Indicated and Inferred Resources), as listed in table 3.7.

3.71 In October 2005 ERA announced that, due to the recent increases in uranium price, it is now economic for the company to lower the cut-off grade down to which it will process uranium ore (from 0.12 per cent to 0.08 per cent U_3O_8). The consequences of the reduction in cut-off grade are that milling operations will now continue at Ranger until 2014 and reserves have been increased. ERA intends to mine at Ranger until at least 2008 and the company has recently been exploring for extensions of the No. 3 orebody.[67]

Table 3.7 Ranger uranium ore reserves and mineral resources as at 31 December 2005

Reserves/Resource classification	**Ore** (Mt)	**Grade** (% U_3O_8)	**Contained U_3O_8** (tonnes)
Ore Reserves			
Current stockpile	9.98	0.15	14 716
Proved	4.48	0.25	11 314
Probable	8.42	0.22	18 428
TOTAL RESERVES	22.78	0.20	44 458
Mineral Resources *(In addition to reserves)*			
Measured	1.42	0.15	2 115
Indicated	12.55	0.14	18 018
Inferred	16.11	0.14	22 454
TOTAL RESOURCES	30.08	0.14	42 587

Source Energy Resources of Australia, *2005 Annual Report*, p. 8.

3.72 In other developments at Ranger, in December 2005 ERA completed construction of a $28 million water treatment plant, which the Committee inspected during its visit to the ranger mine site in October 2005. The plant will ensure that process and other water reaches drinking water standard before it is released from the site to the surrounding environment. In

66 UIC, *Australia's Uranium Mines*, *loc. cit.*; RWE NUKEM, *op. cit.*, p. 19.

67 ERA, *Increase in Ranger Mine's Reserves and Resources*, Media Release and Stock Exchange Announcement, issued 27 October 2005, viewed 26 April 2006, <http://www.energyres.com.au/showpdf.php3?id=199>; GA, *Submission no. 42*, p. 21.

addition to assisting mining operations, it is intended that the plant will eventually become part of rehabilitation plans after the mine's closure.[68]

3.73 Figure 3.4 depicts several Committee members during an inspection of the Ranger mine site, standing on uranium ore stockpiles overlooking the processing plant. Figure 3.5 shows open cut mining of the Ranger No. 3 orebody.

Jabiluka

3.74 ERA holds title to the Jabiluka deposit, situated 22 km north of Ranger. The orebody was discovered in 1971, one year after Ranger, and the NT Government granted a mineral lease in 1982 following the signing of an agreement between the senior Mirarr Traditional Owner and the mining company (Pancontinental Mining). Jabiluka is a world class uranium deposit with total Proved and Probable Reserves of 67 000 t U_3O_8 and an additional 92 000 t U_3O_8 in mineral resources, as listed in table 3.8.[69]

Table 3.8 Jabiluka uranium ore reserves and mineral resources as at 31 December 2005

Reserves/Resource classification	**Ore** (Mt)	**Grade** (% U_3O_8)	**Contained U_3O_8** (tonnes)
Ore Reserves			
Proved	6.40	0.59	38 000
Probable	6.42	0.45	29 000
TOTAL RESERVES	12.82	0.52	67 000
Mineral Resources *(In addition to reserves)*			
Measured	1.80	0.41	7 000
Indicated	3.75	0.39	14 000
Inferred	15.70	0.48	75 000
TOTAL RESOURCES	21.07	0.46	96 000

Source Energy Resources of Australia, *2005 Annual Report*, p. 8.

3.75 Mining at Jabiluka was approved in 1999 subject to over 90 environmental conditions. As with Ranger, Jabiluka is surrounded by, but is not part of, Kakadu National Park. In consideration of World Heritage concerns about the impact of Jabiluka' s development on the park, ERA previously agreed that Jabiluka and the Ranger operation would not be in full operation simultaneously.[70]

68 ERA, *Social and Environmental Report 2005*, p. 12, viewed 27 June 2006, <http://www.energyres.com.au/corporate/ERA_SE_Rep05ART.pdf>; ERA, *2005 Annual Report, op. cit.*, p. 9.

69 GA, *Submission no. 42*, p. 21; ERA, *2005 Annual Report, op. cit.*, pp. 2, 7, 8.

70 GA, *loc. cit.*

Figure 3.4 Committee members standing on ore stockpiles at the Ranger uranium mine in the Northern Territory

Source Energy Resources of Australia.

Figure 3.5 Open pit mining of uranium and processing plant at the Ranger uranium mine

Source Energy Resources of Australia.

3.76 Development of the Jabiluka deposit has been opposed by the Traditional Owners and allied environmental groups. The Traditional Owners have refused to grant approval for development of the mine, with the Mirarr people arguing that they were under duress when they signed the 1982 agreement.[71] The Mirarr and their supporters appeared before the United Nation's (UN) World Heritage Committee to argue that the mine would damage heritage values in the Kakadu region. However, the UN ultimately rejected this contention.[72]

3.77 Following a dialogue with the Mirarr which commenced in 2002, ERA has announced that there will be no further development at Jabiluka without the formal support of the Traditional Owners, and subject to feasibility studies and market conditions.[73]

3.78 In February 2005, the Gundjeihmi Aboriginal Corporation (representing the Traditional Owners), ERA and the Northern Land Council signed an agreement on the long-term management of the Jabiluka lease. This agreement obliges ERA (and its successors) to secure Mirrar consent prior to any future mining development of uranium deposits at Jabiluka. The decline which had previously been sunk at the Jabiluka site has been backfilled and the project site is currently under long-term care and maintenance.[74]

3.79 Mr Harry Kenyon-Slaney, Chief Executive of ERA, explained that ERA is determined to end years of adversarial and acrimonious debate over the future of Jabiluka:

> It is my view, and I think it is also the view of the majority shareholder of ERA [Rio Tinto], that it is very important that you do not bulldoze into people's backyards and develop mining operations without their consent. Clearly, there was not implicit consent, given the adversarial nature of the debate over Jabiluka. Sometimes you have to take a step back before you can move forward. We are now in the process of discussing with the traditional owners what might happen. When the parties are ready, hopefully we will be able to move forward, but that long period of acrimony is still very recent and I think the parties need time to think about the future.[75]

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71 Gundjeihmi Aboriginal Corporation, *Submission no. 44*, p. 4.

72 ERA, *Exhibit no. 76*, p. 8.

73 GA, *Submission no. 42*, p. 21.

74 Mr Harry Kenyon-Slaney, *op. cit.*, p. 48.

75 *ibid.*, p. 50.

Olympic Dam

3.80 The Olympic Dam deposit, which is located 560 km north of Adelaide, was discovered in 1975 by Western Mining Corporation (WMC) which was exploring in the area for copper. After considering geophysical data, a drill hole was sunk near a small stock water dam known as Olympic Dam, named in 1956 after the Olympic Games which took place in Melbourne that year. The speculative surface drilling struck copper and later drilling confirmed a resource of more than 2 000 million tonnes of ore containing both copper and uranium. From 1979 the deposit was developed as a joint venture between WMC and British Petroleum (BP) and production commenced in 1988. WMC, which took over BP Minerals' share in 1993, was acquired by BHP Billiton in July 2005.[76]

3.81 Olympic Dam is the largest known uranium orebody in the world, with an estimated overall resource of more than 1.46 Mt U_3O_8 contained in some 3.9 billion tonnes of ore. The grade of the uranium resource is relatively low at between 0.03 and 0.06 per cent U_3O_8. The orebody starts at a depth of 350 metres and continues down to (at least) 1 000 metres. The mineralisation occurs in a hematite-rich granite breccia complex and lies beneath flat-lying sedimentary rocks of the Stuart Shelf geological province of SA.[77] Olympic Dam's uranium ore reserves and mineral resources as at June 2005 are listed in table 3.9.

Table 3.9 Olympic Dam uranium ore reserves and mineral resources as at June 2005

Reserves/Resource classification	**Ore** (Mt)	**Grade** (% U_3O_8)	**Contained U_3O_8** (tonnes)
Ore Reserves			
Proved	119	0.06	71 000
Probable	642	0.05	321 000
Mineral Resources*			
Measured	650	0.05	325 000
Indicated	1 440	0.04	576 000
Inferred	1 880	0.03	564 000
TOTAL RESOURCES	3 970	0.04	1 465 000

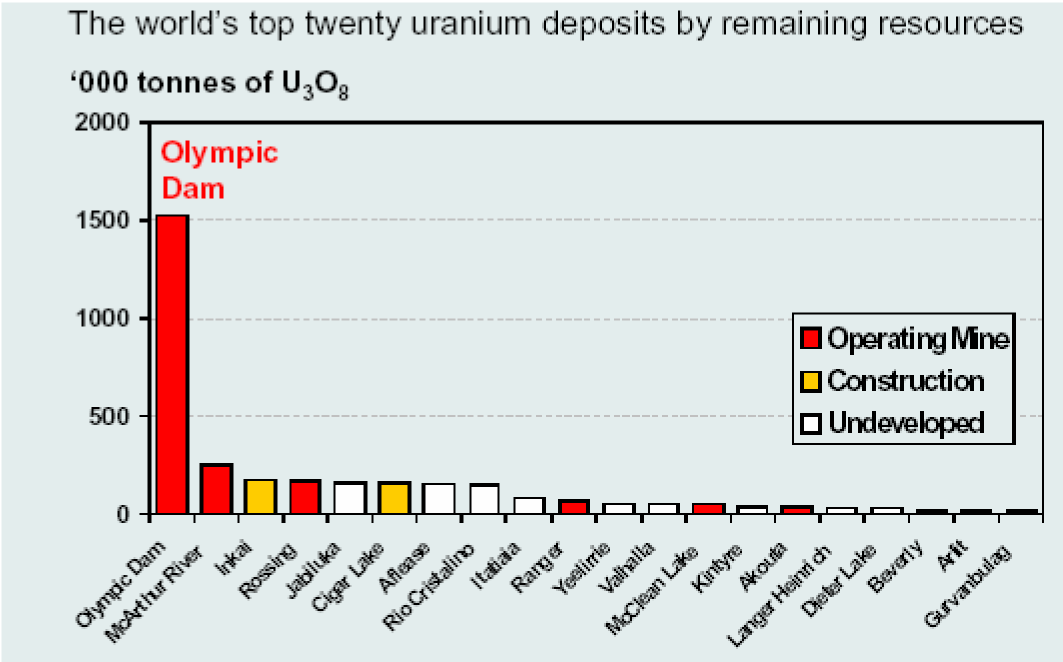
Source Geoscience Australia, *Submission no. 42*, p. 18; BHP Billiton PLC, *Annual Report 2005*, pp. 196–97.
* Measured and Indicated Resources are inclusive of those resources classified as Ore Reserves.

3.82 Despite conducting a large drilling program (a total of 2 270 km of drill core will have been completed by the end of 2007) as part of the pre-feasibility study for its proposed expansion of Olympic Dam (discussed below), BHP Billiton stated that the company has *not* yet defined the limits

76 UIC, *Australia's Uranium Mines*, *loc. cit*; RWE NUKEM, *op. cit.*, p. 5.
77 RWE NUKEM, *op. cit.*, p. 6.

of the orebody in all dimensions. In particular, the boundaries of mineralisation at Olympic Dam are still open to the south and at depth.[78] Figure 3.6 illustrates Olympic Dam's immense size and global significance, ranking it alongside the world's top 20 uranium deposits by quantity of remaining resources.

Figure 3.6 The world's twenty largest uranium deposits by quantity of remaining resources



Source WMC Resources, *Developing the World's Biggest Uranium Resource*, Presentation by Mr Michael Nossal, April 2005, p. 5.

3.83 Olympic Dam is primarily a copper mine and the relatively low average grade of uranium (0.04 per cent U_3O_8) means that Olympic Dam would not support a uranium mine in its own right. The orebody is mined principally for its copper, gold and silver, with uranium as a valuable by-product. Olympic Dam ranks as the world's fourth largest known deposit of copper and fourth largest known deposit of gold.[79] In the mix of products, uranium represents 20–25 per cent of revenue from Olympic Dam, which totalled $1.1 billion in 2004.[80]

3.84 Olympic Dam is a large-scale underground mining operation using sub-level open stoping methods. Between 1989 and 1995, the annual capacity of the processing plant was increased in two stages to 85 000 t copper and

78 BHP Billiton Ltd, *Exhibit no. 78, Presentation by Dr Roger Higgins*, p. 19.

79 RWE NUKEM, *op. cit.*, p. 5.

80 Dr Roger Higgins, *op. cit.*, pp. 3, 5; BHP Billiton Ltd, *Exhibit no. 56, Olympic Dam Development Pre-feasibility Study*, p. 2.

1 700 t U_3O_8 (1 440 tU) plus associated gold and silver from the processing of 3.0 Mt ore per year.[81]

3.85 A major expansion of the project was completed in March 1999 at a cost of $1.94 billion. Annual production capacity was increased to 200 000 t copper, 4 600 t U_3O_8 (3 900 tU), 2 050 kg gold and 23 000 kg silver. To sustain this rate of production, approximately 8.7–9.2 Mt ore are mined and processed annually. Water required for mining and processing operations and for the township of Roxby Downs is pumped from borefields within the Great Artesian Basin (GAB). The main borefield is located more than 175 km north-east of the mine.[82]

3.86 Government approval for the major expansion was granted after a comprehensive EIS was assessed jointly by the Commonwealth and SA Governments. In addition to the existing environmental regulations and controls on the project, new requirements were imposed relating to the management of the GAB water resources, future assessments of the tailings management systems, and impacts of future changes to technology and mining practices.[83]

3.87 GA noted that the metallurgical processes to recover copper, uranium, gold and silver at Olympic Dam are complex, however the processes relating to uranium recovery can be summarised as follows. After crushing and grinding, the ore is mixed with water and the slurry is pumped to the flotation plant. Copper concentrates are produced using standard flotation processes. The non-sulphide particles, which do not float (referred to as flotation tailings), contain most of the uranium minerals. Acid mixed with an oxidant is then added to leach uranium from the flotation tailings, and the slurry is heated to 60°C to improve the leach process. Uranium is recovered from the leach liquor by solvent extraction. Pulsed column technology is used to improve the recovery rate and to reduce the consumption of organic reagents. As at Ranger, the solutions containing dissolved uranium are treated with ammonia and calcined to produce uranium oxide powder.[84]

3.88 In 2005 Olympic Dam produced 4 335 t U_3O_8 (3 676 t U), which was nine per cent of the world's total mine production and the third largest uranium producer. This represented a marginal decrease on 2004 production of 4 370 t U_3O_8 (3 735 tU). However, production from Olympic Dam has continued to expand since mining commenced in August 1988—production in 1988 was 1 180 t U_3O_8, in 1991 it was 1 400 t U_3O_8, in 1993 it

81 GA, *Submission no. 42*, p. 9.

82 *ibid.*

83 *ibid.*

84 *ibid.*

was 1 900 t U_3O_8, and in 1998 it was 4 500 t U_3O_8.[85] Uranium sales are to the US, Canada, Sweden, UK, Belgium, France, Finland, South Korea and Japan.[86]

3.89 The Olympic Dam operation employs 1 670 people of which some 283 people work in the uranium production sector.[87] The scale of Olympic Dam (approximately 6–7 km in length) and the mine's processing plant, smelter and refinery are depicted in figures 3.7 and 3.8.

Proposed expansion of Olympic Dam

3.90 Prior to the acquisition by BHP Billiton, in 2004 WMC commenced a study to investigate the feasibility of a major expansion of the Olympic Dam operations. One of the proposals was an open pit mining expansion that would increase annual uranium production, from some 4 000 t U_3O_8 currently, to approximately 15 000 t U_3O_8, as well as expand copper production to 500 000 t per year and gold to 500 000 ounces per year. This would require mining 40 Mt of ore per year—a four-fold increase in the mining rate.[88] Table 3.10 compares current activity at Olympic Dam with the proposed development.

Table 3.10 Proposed Olympic Dam expansion

	Current	**Proposed (2013+)**
Mine production (per year)	Ore mined = 10 Mt Uranium = 4 000 t Copper = 220 000 t Gold = 80 000 ounces Silver = 800 000 ounces	Ore mined = ~40 Mt Uranium = ~15 000 t Copper = ~500 000 t Gold = ~500 000 ounces Silver = ~2 900 000 ounces
Roxby Downs population	4 100 (average age 27 yrs, 32 per cent under 15 yrs)	Total = 8 000–10 000
Energy (per year)	120 MW, from State grid	Total of ~420 MW, from State grid, on-site gas fired generation, or a combination
Water (per year)	12 GL (32 ML per day), from Great Artesian Basin (GAB)	Total of ~48 GL, from GAB/regional aquifers or coastal desalination (Whyalla area)
Transport In/Out (per year)	1 Mt, by road 12 000 trucks (30 per day)	Total of ~2.2 Mt, by road/rail intermodal or direct rail 26 500 trucks (70 per day)
Exports	Via Port Adelaide	Via Port Adelaide and/or Darwin

Source BHP Billiton, *Exhibit no. 78, Presentation by Dr Roger Higgins*, p. 13.

85 BHP Billiton Ltd, *Exhibit no. 78, op. cit.*, p. 9.

86 UIC, *Submission no. 12*, p. 24.

87 GA, *Submission no. 42*, p. 9. BHP Billiton stated that there are currently 1 750 permanent full-time employees at Olympic Dam. BHP Billiton Ltd, *Exhibit no. 56*, *op. cit.*, p. 18.

88 Dr Roger Higgins, *op. cit.*, p. 6.

Figure 3.7 Processing facilities at Olympic Dam in South Australia

Source BHP Billiton.

Figure 3.8 Aerial view of Olympic Dam

Source BHP Billiton.

3.91 The study for the proposed expansion has included:

- a major drilling program (90 drill holes) to better define the resources in the southern part of the deposit;
- assessing the alternative mining, treatment and recovery methods for the southern part of the deposit;
- identifying and evaluating water and energy supply options; and
- logistics planning that may include linking Olympic Dam to the national rail network.[89]

3.92 Recent drilling has identified significant additional resources in the south-eastern portion of the deposit. The resources as at March 2005 were almost a 35 per cent increase over the resources at December 2003.[90] WMC considered that these resources were 'of sufficient size to support an expanded world-class operation for many decades.'[91]

3.93 Evaluation of the various mining methods and the scale of operations were completed in March 2005. Two mining options were evaluated: underground (sub-level caving or block caving) and open pit. From the results of the study, WMC selected open pit as the preferred method because it provided 'clear economic benefits over the alternatives based upon commercially proven technology.'[92]

3.94 The mine's current owners, BHP Billiton, are now undertaking an extensive pre-feasibility study (PFS) for the proposed expansion, with the study expected to be completed by October 2007. Under the company's capital investment procedures, the PFS is the predominant decision making activity, with only a brief feasibility study, of perhaps one year's duration, to follow. BHP Billiton will expend approximately $300 million on the PFS and a further $100 million on the feasibility study.[93] The objectives of the study are to:

- identify the mine's total resource base;
- select a single preferred, sustainable life of mine plan;
- identify financing needs;
- identify implementation requirements; and
- assess strategic implications of the preferred development option.[94]

89 BHP Billiton Ltd, *Exhibit no. 78, op. cit.*, p. 12.

90 GA, *Exhibit no. 61*, *op. cit.*, p. 9.

91 Cited in GA, *Submission no. 42*, p. 19.

92 *ibid*; BHP Billiton Ltd, *Exhibit no. 78, op. cit.*, p. 18.

93 Dr Roger Higgins, *op. cit.*, p. 7. Total expenditure on feasibility studies will amount to approximately 10 per cent of the project's total costs.

94 BHP Billiton Ltd, *Exhibit no. 56, op. cit.*, p. 14.

3.95 It is expected that by late 2007, or early 2008, BHP Billiton will have decided on the size and shape of the expansion project. An Environmental Impact Study will be completed by the end of 2007. The feasibility study phase is expected to be completed by early 2009, with construction (the execution phase) commencing in that year and continuing for four years until 2013. The expanded facilities are expected to become operational in 2013.[95]

3.96 As the mineralisation at Olympic Dam commences at about 300 metres below surface, the execution phase will require the removal of a substantial overburden, amounting to one billion tonnes of rock that will need to be pre-stripped. During this phase, it is likely that production will continue from underground, but begin to diminish as the open pit starts up. It is expected that the underground and open pit operations will run in parallel for up to eight years.[96] The dimensions of the completed pit will be approximately three kilometres across and one kilometre deep.[97]

3.97 The proposed expansion would more than treble uranium production from the mine and, in doing so, double Australia's current national production.[98] Olympic Dam would become the world's largest uranium producer, accounting for over 20 per cent of total world production annually. Furthermore, the quantity of remaining uranium resources means that Olympic Dam could be mined at the expanded rate for over 70 years. WMC estimated that once the expansion is complete, uranium production will contribute 35–40 per cent of revenues from the mine.[99]

3.98 The majority of the mine's workforce of some 1 750 employees (with a similar number of permanent contractors) live at Roxby Downs, located 15 kilometres to the south of the mine. The town, which was developed by the mine, currently has a population of 4 000. The expanded mine would double the workforce, requiring an expansion of the town and its facilities.

3.99 As listed in table 3.9, BHP Billiton is studying options to provide water (including possible construction of a desalination plant located near Whyalla and piping the water inland, a distance of 300 km), power (including gas piped from Moomba) and transport (including the

95 BHP Billiton Ltd, *Exhibit no. 78, op. cit.*, p. 15; Dr Roger Higgins, *op. cit.*, p. 8.

96 Dr Roger Higgins, *op. cit.*, p. 9.

97 BHP Billiton Ltd, *Exhibit no. 78, op. cit.*, p. 18.

98 Mr Aden McKay, *op. cit.*, p. 3.

99 BHP Billiton Ltd, *Exhibit no. 78, op. cit.*, p. 3; Dr Roger Higgins, *op. cit.*, p. 3; WMC Resources Ltd, *Developing the World's Biggest Uranium Resource*, Presentation by Mr Michael Nossal, April 2005, p. 9.

construction of a rail link between Pimba and Olympic Dam of 90 km) for the expanded mine.[100]

3.100 The proposed expansion would involve an investment of up to US$5 billion. The four-year execution phase would employ an average of some 5 000 construction workers, with a peak of up to twice this number.[101] Chapter nine discusses Olympic Dam's economic significance and the benefits that may flow from the proposed expansion of the mine. Some submitters were critical of the proposed expansion, primarily on the grounds of the possible environmental impacts, and these concerns are summarised in chapter ten.

3.101 In relation to its other uranium asset in Australia, the Yeelirrie deposit in WA (Australia's third largest uranium deposit), BHP Billiton stated that 'at the moment, opening Yeelirrie is not an option.'[102]

Beverley

3.102 The Beverley uranium deposit, which is located 520 km north of Adelaide and adjacent to the northern Flinders Ranges on the plains north-west of Lake Frome, is a relatively young sandstone deposit with uranium mineralisation leached from the Mount Painter region. The deposit was discovered in 1969 and purchased by its current owners, Heathgate Resources (a wholly-owned subsidiary of General Atomics of the US), in 1990. The deposit consists of three mineralised zones (north, central and south) in a buried palaeochannel (the Beverley aquifer) at a depth of between 100 and 130 metres below surface, and 10 to 20 metres thick. The aquifer is isolated from other groundwater, most notably the GAB, which is about 150 metres below it, and small aquifers above it which are used for stock watering.[103]

3.103 The Beverley project is Australia's first commercial in situ leach (ISL) uranium mining operation. At Beverley, uranium occurs in porous sandstones saturated with groundwater. GA and the UIC explained the ISL technology as follows. Uranium is leached in situ using sulphuric acid and an oxidant (hydrogen peroxide) which is introduced into the sandstones via injection wells. The leach solutions containing dissolved uranium are then pumped to the surface via production (extraction) wells and into the processing plant. Thus, the Beverley mine consists of wellfields which are progressively established over the orebody as uranium is depleted from sections of the orebody immediately

100 Dr Roger Higgins, *op. cit.*, pp. 6–7.

101 *ibid.*, p. 16.

102 Dr Roger Higgins, *op. cit.*, p. 21.

103 UIC, *Australia's Uranium Mines, loc. cit.*

underneath. Wellfield design is on a grid with alternating extraction and injection wells, each identical to typical water bores. The spacing between injection wells is about 30 metres with each pattern of four having a central extraction well. Monitor wells are situated to detect any leakage of mining fluids into other aquifers.[104] Figure 3.9 shows Committee members inspecting one of the extraction wells at the Beverley uranium mine.

3.104 Uranium is recovered in the processing plant using ion-exchange technology. The final product is hydrated uranium oxide ($UO_4.2H_2O$) which is a yellow powder, also referred to as 'yellowcake'. This is heated in a low temperature zero-emissions dryer to remove moisture and residual chemical reagents.[105] Figure 3.10 shows Committee members with drums of yellowcake at Beverley being prepared for shipping.

3.105 Production from the northern zone at Beverley commenced in 2000. In 2005 the mine produced 977 t U_3O_8, which was marginally less than 2004 production of 1 084 t U_3O_8.[106] Heathgate Resources aims to increase the mine's capacity to 1 500 t U_3O_8 per year and plans to achieve this level of production in 2009.[107]

3.106 Beverley is the world's largest single ISL uranium mine. In 2004, production from Beverley was greater than total US production, which was from a number of ISL operations in Wyoming, Nebraska and Texas. In 2005 Beverley accounted for two per cent of world mine output. Beverley has sales contracts with utilities in the US, Japan, South Korea and Europe and the mine employs some 180 people.[108]

3.107 Mr Mark Chalmers, the former Senior Vice President and General Manager of Heathgate Resources, argued that:

> … whilst small in comparison to Olympic Dam and Ranger, [Beverley] is important in terms of setting a standard for the small and medium sized producers of the future. Our mine is the most technologically advanced ISL uranium mine in the world. It is equipped with the latest instrumentation and controls. Our method of extraction minimises environmental impact and health and safety impacts to our employees and to the public.[109]

104 GA, *Submission no. 42*, p. 10; UIC, *Australia's Uranium Mines, loc. cit.*

105 *ibid.*

106 UIC, *Australia's Uranium Mines, loc. cit.*

107 Heathgate Resources Pty Ltd, *Exhibit no. 57, General Information Document*, p. 1.

108 GA, *Submission no. 42*, p. 10; UIC, *Submission no. 12*, p. 24.

109 Mr Mark Chalmers (Heathgate Resources Pty Ltd), *Transcript of Evidence*, 19 August 2005, p. 96.

Figure 3.9 Committee members inspecting an extraction well at the Beverley in-situ leach uranium mine in South Australia

Figure 3.10 Committee members with drums of yellowcake (hydrated uranium peroxide) in a container being prepared for shipping at the Beverley uranium mine

3.108 As at April 2005, the Beverley deposit contained 5 897 t U_3O_8 in Proved and Probable Reserves. The deposit contains an overall resource of 21 600 t U_3O_8 at a grade of 0.18 per cent.[110]

3.109 During 2003, ISL mining at Beverley progressed from the deposit's north orebody into the much larger central orebody. Installation of the main pipelines (trunklines) connecting the plant to the central orebody was completed and, by early 2004, production reached an annualised rate of 1 000 t U_3O_8, the licensed capacity of the plant at that time.

3.110 Commonwealth and SA Government agencies have recently considered a proposal from Heathgate Resources to optimise the Beverley operations to produce up to 1 500 t U_3O_8 per year. Geoscience Australia and the Bureau of Rural Sciences (BRS), which provided technical advice on this proposal to the Australian Government Departments of Industry (DITR) and the Environment and Heritage (DEH), advised that the company should be required to undertake groundwater studies to determine the hydrological impacts on the Beverley aquifer which could result from increased rates of disposal of liquid wastes from the ISL operations.

3.111 GA informed the Committee that in 2004, after considering this technical advice together with further reports from the company, the Minister for Industry, Tourism and Resources approved the extension and granted Heathgate Resources a new uranium export permit. As part of the export permit, the Minister imposed a number of conditions including, inter alia, that the Beverley operations are to be carried out on the basis of a neutral water balance; that is, the total volume of fluid injected into the aquifer from all sources must equal the total volume pumped out.[111]

3.112 In 2004 Heathgate Resources announced the discovery of a new zone of uranium mineralisation approximately three km south of the Beverley deposit. This ore zone, referred to as the Deep South zone, was discovered using a range of geophysical surveys followed up by an extensive drilling program comprising more than 120 holes totalling 23 745 metres. The Deep South ore zone is within sands similar to the main Beverley deposit. Resource estimates for this zone have not been reported to date.

3.113 The company has also recently reported other discoveries in and around the Beverley mine area in addition to the Deep South zone. These more recent discoveries are new and require additional follow-up, however, the

110 Heathgate Resources Pty Ltd, *Exhibit no. 57, op. cit.*, p. 2; UIC, *Australia's Uranium Mines, loc. cit*; P Abbot, 'Uranium in South Australia', *Earth Resources Information Sheet*, Primary Industries of SA, Adelaide, March 2006, p. 1, viewed 30 June 2006, <http://www.pir.sa.gov.au/byteserve/minerals/references/info_sheets/m50_web.pdf>.

111 GA, *Submission no. 42*, p. 20.

success of on-going exploration is expected to increase the life of the project.[112]

3.114 ISL mining has numerous advantages over traditional excavation techniques, including: minimal disturbance to the land surface; no excavation of large volumes of overburden or mine wastes; a simple processing plant with no crushing or grinding required; no large volumes of tailings or tailings dams; no exposure of the orebody to the atmosphere; reduced radiation exposure to workers and the public; and relatively simple rehabilitation requirements.[113] However, for the ISL mining method to be applicable requires unique geological and hydrological conditions. In general, the deposits need to be located in sedimentary permeable zones. Heathgate Resources estimated that ISL would be applicable to some 15 to 20 per cent of uranium deposits worldwide. In addition to Beverley, other in situ leachable uranium deposits in Australia include Honeymoon and Goulds Dam in SA, and Oobagooma and Manyingee in WA.[114]

3.115 The Committee received some evidence that was critical of the environmental impacts of ISL mining and these are considered in chapter ten.

Other industry developments

3.116 In addition to the industry developments described above, evidence to the inquiry mentioned the likely development of the Honeymoon deposit in SA and the problematic issue of recovering uranium from brannerite ores, such as those at Olympic Dam and the Valhalla deposit in Qld.

Honeymoon Project

3.117 The Honeymoon deposit, located 75 km north west of Broken Hill in South Australia (see figure 3.2), was discovered in 1972 and is contained within unconsolidated sands at a depth of 100 metres in the Yarramba palaeochannel. The deposit extends over 150 hectares. Honeymoon, along with the adjacent East Kalkaroo deposit and the Goulds Dam–Billaroo West deposits (located 80 km north west of Honeymoon–East Kalkaroo), were acquired by Canadian company Southern Cross Resources in 1997. In 2005, Southern Cross Resources merged with South African companies Aflease Gold and Uranium Resources to form sxr Uranium One, which

112 *ibid.*, p. 21.

113 I Dobrzinski, *Beverley and Honeymoon uranium projects*, MESA Journal, April 1997, p. 11.

114 Mr Mark Chalmers, *op. cit.*, p. 98.

has a primary listing on the Toronto stock exchange. Uranium One also owns uranium and gold projects in South Africa.[115]

3.118 Honeymoon and East Kalkaroo contain 4 200 t U_3O_8.[116] Table 3.11 summarises the resource estimates for both the Honeymoon and Goulds Dam deposits.

3.119 Southern Cross Resources submitted an initial EIS to develop the Honeymoon deposit in June 2000. Following the approval of the EIS, the company was granted an export license by the Commonwealth Government in November 2001.[117] Following the conclusion and signing of a Native Title Agreement with the Adnyamathanha people (a similar agreement with the Kuyani people was concluded in 1998), the State Government granted Southern Cross Resources a mining lease to develop Honeymoon as an ISL project in February 2002.[118] The current State Government reportedly considers that the project is an existing mine, because the mining lease was granted by the previous State Government, and will therefore allow the mine to proceed.[119]

Table 3.11 Mineral resources for Honeymoon, East Kalkaroo, Goulds Dam and Billeroo

Deposit	**Resource category**	**Million tonnes**	**Average grade** (% U_3O_8)	**Contained U_3O_8** (tonnes)
Honeymoon*	Indicated	1.2	0.24	2 900
East Kalkaroo	Indicated	1.2	0.074	910
Goulds Dam	Indicated	5.6	0.045	2 500
Billeroo	Inferred	12.0	0.03	3 600
Total Resources				**10 310**

Source Southern Cross Resources, *2004 Annual Report*, p. 6
* Resource figures for Honeymoon from sxr Uranium One, *sxr Uranium One Announces Honeymoon Feasibility Study and Approves Honeymoon Project*, News Release, 29 August 2006.

3.120 In 2004 Southern Cross Resources commissioned a cost and engineering study for a plant at Honeymoon with a design capacity of 400 t U_3O_8 per

115 UIC, *Australia's Uranium Deposits and Prospective Mines, loc. cit.*; SXR Uranium One Inc, company information, viewed 3 July 2006, <http://www.uranium1.com/index.php?section=company&page=0>.

116 Southern Cross Resources Inc, *2004 Annual Report*, p. 5, viewed 3 July 2006, <http://www.uranium1.com/uploads/report/AR2004.pdf>.

117 The export permission authorises exports of uranium from Honeymoon for five years commencing 1 January 2002.

118 GA, *Submission no. 42*, p. 22; sxr Uranium One Inc., *sxr Uranium One Inc. submits application to commercially mine and mill radioactive ore at Honeymoon*, News Release, 25 May 2006, viewed 3 July 2006, <http://www.uranium1.com/uploads/articles/Application%20To%20Mine%20and%20Mill_25.PDF>.

119 See: C England, 'Uranium mine "to proceed"', *Adelaide Advertiser*, 2 May 2006, p. 31; M Wiese Bockmann, 'Nuclear minefield', *The Australian*, 31 August 2006, p. 12.

year and a mine life of six to eight years. However, the company decided to defer production pending higher uranium prices.[120]

3.121 In May 2006 Uranium One submitted an application for a license to commercially mine uranium at the Honeymoon site to the SA Environment Protection Authority (EPA). The license application relates to mine design, radiation and waste management, and rehabilitation.[121] In June 2006 the company completed feasibility studies and additional drilling to better define the Honeymoon and East Kalkaroo deposits. Subject to State Government approval of the subsidiary plans, the Board of Uranium One was expected to decide on whether to proceed with production in mid 2006. Plant construction is expected to take less than 18 months with production commencing in the first quarter of 2008.[122]

3.122 In August 2006 the Board of Uranium One announced that it had approved the development of the deposit.[123] The Honeymoon project, which will be an acid ISL operation similar to the Beverley uranium mine, is expected to produce a total of 2 400 t U_3O_8 over a period of seven years. The project will employ approximately 50 people.[124]

Recovery of uranium from brannerite ores

3.123 At Olympic Dam, Ranger and many other uranium mines worldwide, sulphuric acid is used to dissolve uranium minerals from uraninite ores using conventional acid leach plants. However, brannerite, which is another important uranium mineral, is not dissolved in these sulphuric acid plants. The consequence is that less uranium is recovered after processing these ores and the brannerite is sent to tailings dams for disposal. This was confirmed by the Australian Atomic Energy Commission during the 1960s, after research on bulk metallurgical samples from brannerite-rich mineralisation at the Valhalla deposit in Qld.[125]

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120 Southern Cross Resources Inc, *loc. cit.*

121 sxr Uranium One Inc., *sxr Uranium One Inc submits application to commercially mine and mill radioactive ore at Honeymoon, loc. cit.* The Honeymoon project application, along with the company's EIS and proposed radiation management and radioactive waste management plans are available online at the EPA web site, viewed 3 July 2006, <http://www.epa.sa.gov.au/honeymoon.html>.

122 Personal communication with Mr Greg Cochran, Executive Vice President, Australia and Asia, sxr Uranium One Inc., 3 July 2006.

123 sxr Uranium One Inc., *sxr Uranium One Announces Honeymoon Feasibility Study and Approves Honeymoon Project*, News Release, 29 August 2006, viewed 31 August 2006, <http://www.uranium1.com/uploads/articles/HoneymoonFeasibility_29Aug06.pdf>.

124 sxr Uranium One Inc., *Honeymoon Project Application License to Mine or Mill Radioactive Ore*, p. 4, viewed 3 July 2006, <http://www.epa.sa.gov.au/pdfs/honeymoon_application.pdf>.

125 GA, *Submission no. 42*, p. 22.

3.124 GA argued that this is a key issue for the Australian uranium industry because cost effective processes to recover uranium from brannerite would result in a significant increase in Australia's recoverable low cost resources of uranium. As noted above, under the IAEA and OECD-NEA resource classification scheme, Identified Resources are quantified as *recoverable* uranium—that is, after mining and processing losses have been deducted. This issue is of particular importance for Australia because much of the uranium at Olympic Dam (approximately 30 per cent) is contained in brannerite and only about 70 per cent of the uranium is recovered.[126] Hence, if uranium recoveries from Olympic Dam could be increased it would mean much greater production of uranium from the same quantity of ore, and therefore have a dramatic effect on the quantity of Australia's overall recoverable uranium resources.

3.125 GA noted that the mine's former owners, WMC Resources, commenced a major research program to improve uranium recoveries, including testing various new recovery techniques such as elevating the temperature of the leach tailings.[127] During 2004 the company implemented a first phase of these metallurgical improvements and reported recoveries as high as 77 per cent. GA argued that:

> The implications of these results are far reaching because, if they can improve recoveries up to 85% (as proposed), this will have a marked improvement in production and revenues. In the lower grade ores at Olympic Dam, the ratio of brannerite:uraninite increases with decreasing ore grade. It is very important for future expansions of the operations into the southern section of the orebody (lower grade) that this brannerite problem be solved.[128]

3.126 Summit Resources stated that its metallurgical test work indicates a potential overall recovery of around 75 per cent of the uranium at the Valhalla deposit in Mount Isa.[129]

3.127 Before turning to a discussion of exploration and the potential for further discoveries of uranium in Australia, the Committee notes again a conclusion of the previous chapter—that there is great potential for Australia to expand production and become the world's premier supplier of uranium.

3.128 The UIC submitted that 'Australia is a preferred supplier to the world' and GA argued that 'Australian uranium mining companies have gained a

126 *ibid*. See also: See also: Dr Gavin Mudd, *Transcript of Evidence*, 19 August 2005, p. 50; Dr Gavin Mudd, *Submission no. 27*, p. 9.

127 Mr Aden McKay (GA), *Transcript of Evidence*, 5 September 2005, p. 6.

128 GA, *Submission no. 42*, p. 23.

129 Summit Resources Ltd, *op. cit.*, p. 14; Mr Aden McKay (GA), *op. cit.*, p. 7.

reputation as reliable suppliers to customer countries and utilities.'[130] Similarly, ASNO argued that:

> As a stable, secure low-cost uranium producer Australia is likely to occupy a key position in world uranium supply. Not only does Australia hold the largest uranium reasonably assured recoverable resources, it also holds a significant share of the market in areas where nuclear power is expanding; principally, North Asia.[131]

3.129 Likewise, the Australian Nuclear Association (ANA) submitted that:

> Australia is a preferred uranium supplier in many markets, not only due its low cost high-quality product, but also because it is seen to have high economic and political stability.[132]

3.130 Moreover, Nova Energy argued that, unlike some other supplier countries, the Australian minerals industry can properly claim to be a 'mature, high technology and heavily regulated industry', where stringent safety and environmental regulations are imposed.[133]

Exploration

3.131 The Australian Bureau of Statistics (ABS), which produces official exploration data for Australia, records that uranium exploration expenditure amounted to $20.7 million during financial year 2004–05. This figure was almost double the 2003–04 total of $10.5 million, which in turn was an increase on the 2002–03 figure of $6.9 million. In the first half of 2005–06, exploration expenditure totalled $27.7 million, already exceeding expenditure of the entire previous year.[134]

3.132 GA also undertakes an annual survey of uranium exploration in Australia, reporting expenditures on a calendar year basis. As with the ABS findings, GA has reported a significant increase in uranium exploration since early 2003. In 2005, total expenditure on uranium exploration was $41.09 million, which was the highest since 1988 (in constant 2005A$) and almost a three-fold increase on 2004 expenditure of $13.96 million. Exploration

130 UIC, *Submission no. 12*, p. 27; GA, *Submission no. 42*, p. 11. See also: Deep Yellow Ltd, *Submission no. 16*, p. 2.

131 ASNO, *Submission no. 33*, p. 6.

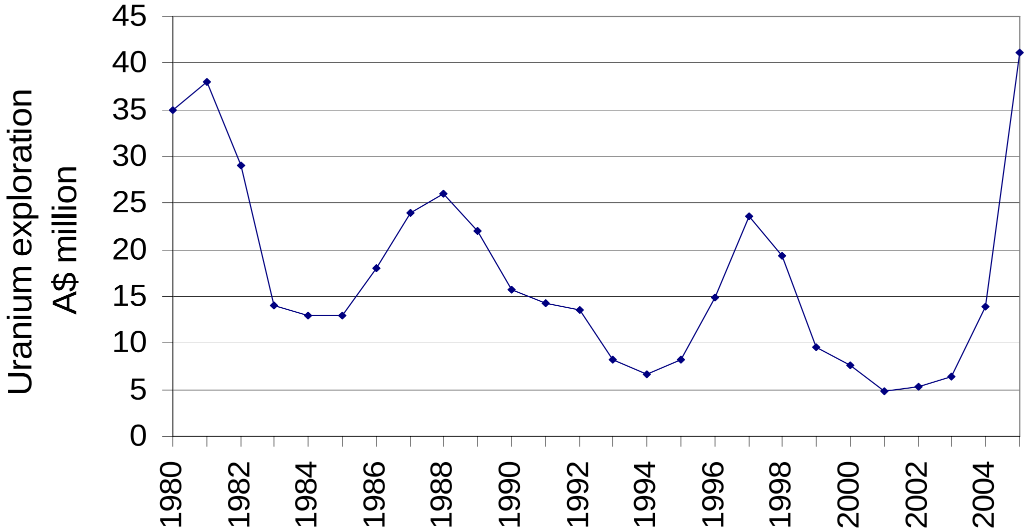
132 ANA, *Submission no. 19*, p. 2.

133 Nova Energy Ltd, *op. cit.*, p. 9.

134 ABS, *Mineral and Petroleum Exploration*, cat. no. 8412.0, ABS, Canberra, 2005, p. 12, viewed 23 June 2006, <http://www.abs.gov.au>.

expenditure in 2003 was \$6.38 million.[135] Figure 3.11 shows uranium exploration expenditure in Australia since 1980.

Figure 3.11 Uranium exploration expenditure in Australia 1980–2005



Source Geoscience Australia
Annual expenditures are nominal, dollar of the day, figures and have not been adjusted for inflation.

3.133 GA argued that exploration expenditure has risen for three principal reasons: the rise is uranium spot market price, which has increased four-fold from US\$10/lb U_3O_8 in early 2003 to more than \$45/lb U_3O_8 in June 2006; the rise in crude oil prices; and the perception in the market that secondary supplies of uranium are being exhausted. These factors were discussed in chapter two.[136]

3.134 GA observed that, historically, uranium exploration in Australia has been highly successful. The majority of Australia's uranium deposits were discovered between 1969 and 1975—approximately 50 deposits were discovered during this short period, including several world-class deposits such as Ranger, Jabiluka, Nabarlek and Koongarra in the Alligator Rivers region (NT); Olympic Dam and Beverley (SA); and Yeelirrie in Western Australia (WA). From 1975 to 2003, only another four deposits were discovered and of these only one deposit (Kintyre in the

135 GA, *Exhibit no. 62*, *op. cit.*, p. 4. Exploration expenditure for 2005 provided by Mr Aden McKay (GA), 26 June 2006.

136 Mr Aden Mackay (GA), personal communication, 3 February 2006.

Paterson Province of WA) has RAR recoverable at less than US$40/kg U.[137]

3.135 Despite steady growth in mining and exports, expenditures on uranium exploration in Australia fell progressively for 20 years, from a peak level of $35 million ($105 million in constant 2003A$) in 1980 to a historic low of $4.8 million in 2001 ($5.34 million in constant 2005A$).[138] The increase in expenditure that culminated in the 1980 peak was in large part due to the oil shocks of 1973 and 1979, which GA noted strongly resembles the current situation of high crude oil prices.[139]

3.136 During the late 1970s and early 1980s, up to 60 companies were actively exploring for uranium in Australia. Exploration was carried out in 'greenfields' areas, as well as the known uranium provinces. Subsequently, expenditures declined to 2001, when only five companies were actively exploring for uranium in areas adjacent to known deposits, mainly in western Arnhem Land (NT), the Frome Embayment and the Gawler Craton-Stuart Shelf (SA). This long decline was interrupted by two brief periods of increasing expenditures following the discovery of the Kintyre deposit in 1985, and the abolition of the 'Three mines' policy by the Commonwealth Government in 1996.[140] The decline in exploration expenditure resulted from several factors:

- falling uranium prices over two decades—prices fell from an average of US$42.57/lb U_3O_8 in 1979 to an average of $8.30/lb U_3O_8 in 2002;
- restrictions in some jurisdictions on uranium exploration and production;
- increasing availability of supplies from secondary sources (mainly highly enriched uranium stocks); and
- decreasing costs of production resulting from large-scale, low-cost mining in Canada and Australia.[141]

Figure 3.12 plots uranium exploration expenditure in Australia and the spot price for uranium from 1967 to 2003.

137 GA, *Exhibit no. 61, op. cit.*, p. 5.

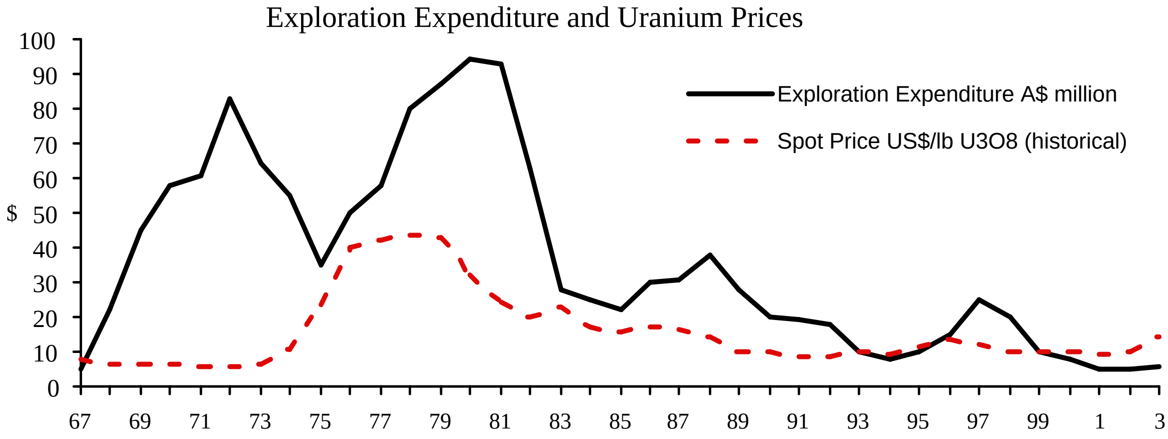
138 *ibid.*; GA, *Australia's Identified Mineral Resources 2002*, GA, Canberra, 2002, p. 51, viewed 4 July 2006, < http://www.ga.gov.au/image_cache/GA3309.pdf>.

139 McKay and Miezitis, *op. cit.*, p. 8; I Lambert, et. al., *op. cit.*, p. 2.

140 GA, *Submission no. 42*, p. 23.

141 *ibid.* For a detailed history of uranium exploration in Australia see McKay and Miezitis, *op. cit.*, pp. 5–9.

Figure 3.12 Exploration expenditure and uranium prices (1967–2003)



Source UIC, *Submission no. 12*, p. 13.

3.137 Cameco noted that the decline in exploration expenditure resulted in activity being focussed in relatively few areas, including the Frome Embayment in SA, the ARUF in the NT and, in the early 1980s, the Rudall Province of WA. However, apart from limited activity in these areas, 'exploration has effectively stopped in the rest of Australia for the past twenty years.'[142]

3.138 Despite the paucity of discoveries since 1985, Australia's low-cost resources have continued to increase as a result of the delineation of additional resources at known deposits, mostly at Olympic Dam.[143] Figure 3.13 illustrates exploration expenditure, discovery of deposits and the increase in low-cost resources over the period 1967 to 2004. While there has been a trend of increasing exploration expenditure since early 2003, there has been relatively little exploration for uranium over the past two decades and Australia's known uranium resources generally reflect exploration efforts that took place 30 years ago. As the UIC argued:

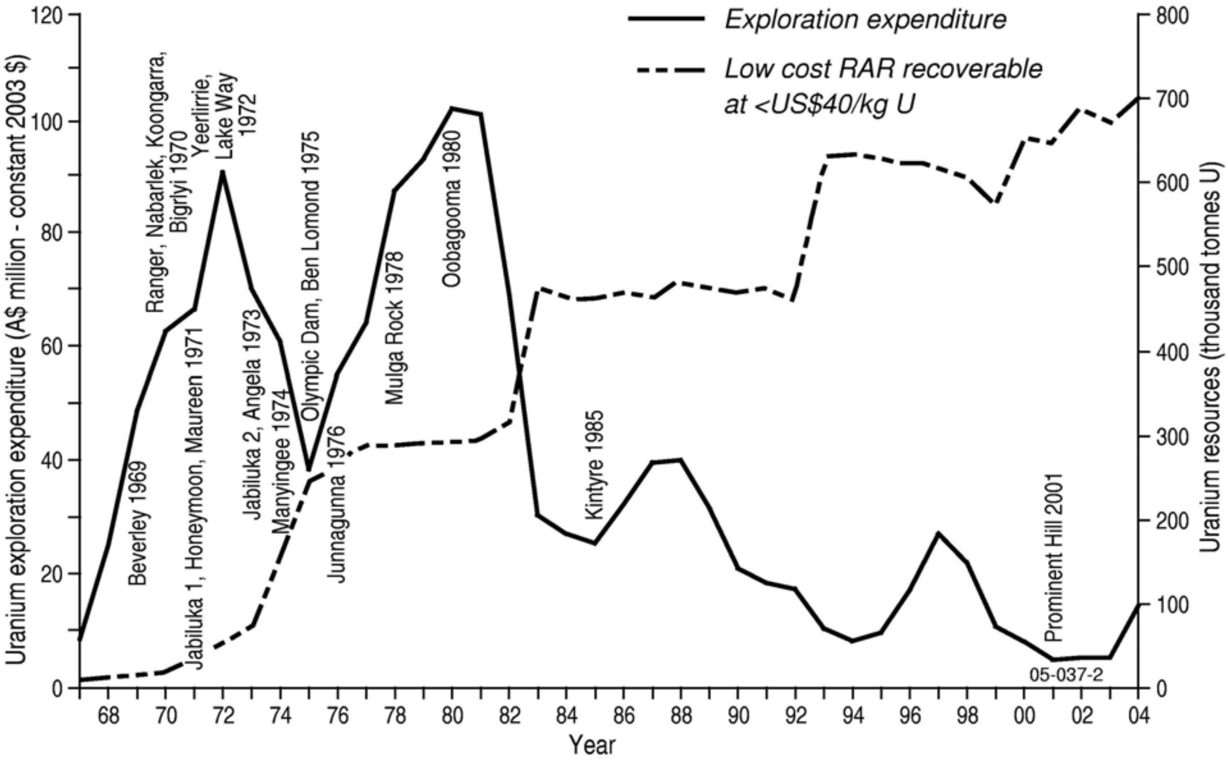
> It can thus be seen that Australia's known uranium resources largely reflect exploration efforts more than 25 years ago. Very little exploration for uranium has been carried out since. There is now significant potential for increasing exploration in the light of higher uranium prices, but state government policies need to be positive.[144]

142 Cameco Corporation, *op. cit.*, p. 4.

143 GA, *Submission no. 42*, p. 23.

144 UIC, *Submission no. 12*, p. 25.

Figure 3.13 Trends in uranium exploration expenditures, discovery of deposits and the increase in Australia's low cost resources



Source Geoscience Australia, *Exhibit no. 60, Australia's uranium resources, production and exploration*, p. 9.

Recent exploration activity

3.139 The marked uranium price rise since 2003 (see figure 2.6 in chapter two) has stimulated a significant resurgence in exploration activity. In 2004 there were 14 active uranium exploration projects in Australia, while in 2005 the number of active projects had increased to 70. The number of companies actively exploring for uranium increased from five at the start of 2004 to more than 34 by late 2005.[145]

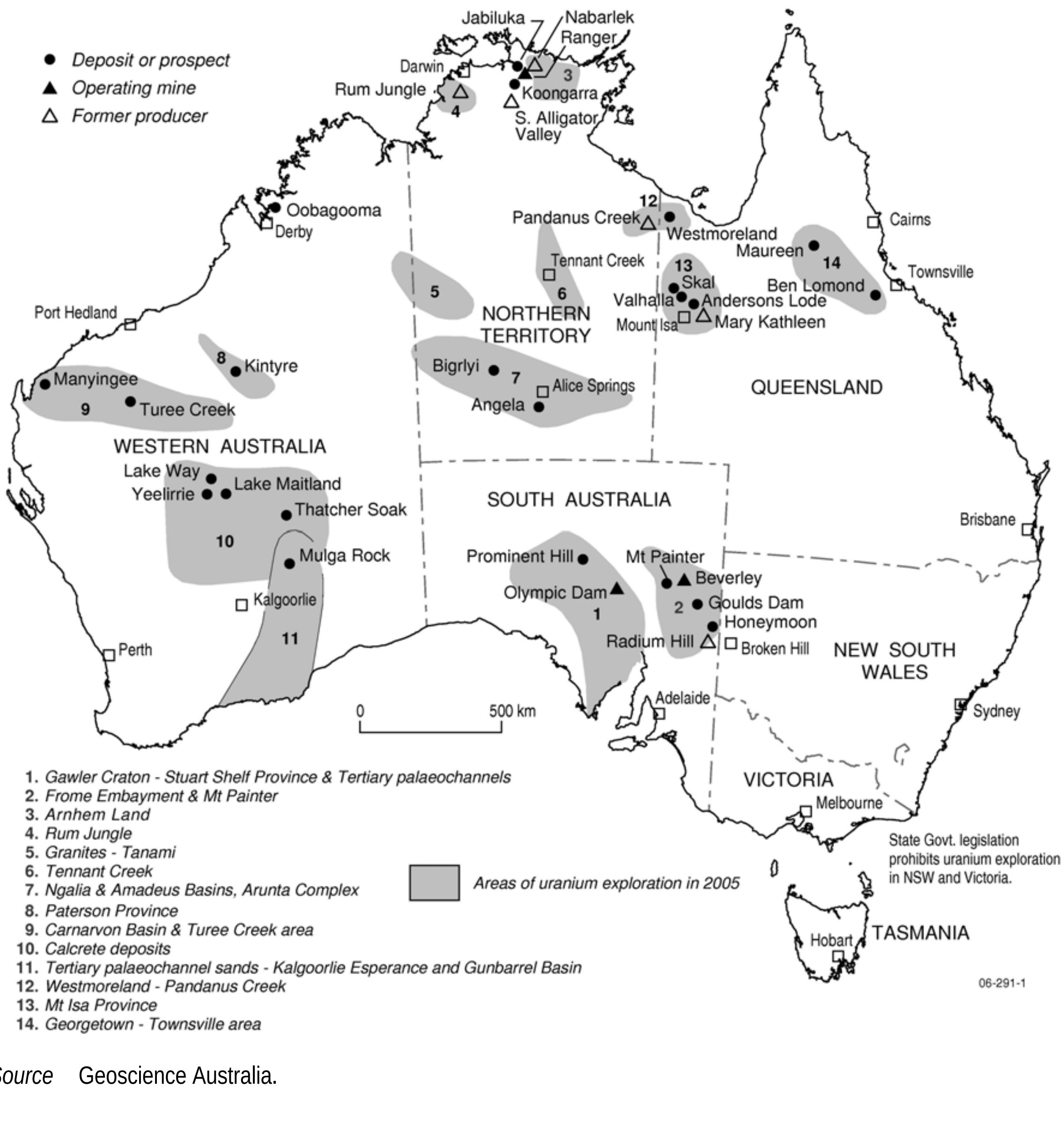
3.140 The proportions of total exploration expenditure spent in each jurisdiction in 2005 were: SA 42 per cent, NT 37 per cent, Qld 15 per cent and WA 6 per cent. The majority of expenditure was in SA and NT which together accounted for almost 80 per cent of the total. The main areas (in terms of expenditure) of exploration, which are illustrated in figure 3.14, were:

- South Australia—Gawler Craton-Stuart Shelf region; Tertiary palaeochannel sediments of the Frome Embayment; and palaeochannels overlying the Gawler Craton;

145 Information provided by Mr Aden McKay (GA), 5 July 2006, from the findings of the 2005 uranium exploration survey.

- Northern Territory—Alligator Rivers region and Western Arnhem Land, and Ngalia Basin (including Napperby project in Tertiary sediments overlying the Ngalia Basin); and
- Queensland—Mount Isa province.[146]

Figure 3.14 Areas of uranium exploration in 2005



Source Geoscience Australia.

146 *ibid*.

3.141 Important uranium exploration results in 2005 included:

- discovery of major extensions of the Olympic Dam deposit to the south-east, and the proposal to test the deeper zones of mineralisation down to depths of 2.5 km below surface (currently resources have been evaluated to a depth of 1 km below surface);
- discovery of a new deposit, Beverley 4 Mile, which is 5–10 km west of the Beverley mine, and continued discovery of further mineralisation to the south of the Beverley mine; and
- discovery of extensions to the Valhalla, Skal and Andersons deposits and significant intersections in the Bikini and Mirrioola deposits.[147]

3.142 In other developments, GA noted that in 2005 Bullion Minerals explored for sandstone-hosted uranium deposits in Tertiary sands overlying granitic basement rocks in the Kalgoorlie–Esperance region of WA. This is the first time that uranium exploration has been undertaken in this area. Exploration also re-commenced in many geological provinces in which the last exploration for uranium occurred more than 20 years previously.[148]

3.143 In 2004–05 Southern Cross Resources and Heathgate Resources conducted drilling in areas of the Frome Embayment area of SA, which had first been identified by airborne electromagnetic surveys that defined the extent of buried palaeochannels. These activities were directed at exploring for sandstone-type deposits. As noted above, Heathgate Resources announced the discovery of a new zone of uranium mineralisation 3 km south of Beverley (the Deep South zone).[149]

3.144 In 2004 Southern Cross Resources discovered a new zone of low-medium grade uranium mineralisation in the area of the Yarramba palaeochannel, approximately 1.5 km north-west of the Honeymoon deposit, known as the Brooks Dam prospect. The grade and thickness of mineralisation were measured using a 'Prompt Fission Neutron' probe technology, which gives more reliable uranium grades than probes normally used in sandstone-hosted uranium deposits. Southern Cross Resources also completed airborne electromagnetic surveys and ground gravity surveys over the Billeroo region and defined the extent of the Billeroo palaeochannel. A program of drilling was also conduced to evaluate the resources at the Goulds Dam prospect. In August 2005, Marathon Resources announced an inferred resource of 33 200 t U_3O_8 at its Mount Gee prospect in the Curnamona Province of SA.[150]

147 *ibid*.

148 *ibid*.

149 GA, *Exhibit no. 61, op. cit.*, p. 9.

150 GA, *Exhibit no. 62, op. cit.*, pp. 4–5.

3.145 The Beverley 4 Mile prospect, owned by Alliance Resources/Quasar Resources, is important because, if current interpretations prove to be correct, it represents the first known discovery of significant uranium mineralisation within Mesozoic sediments in SA. GA explained that this highlights the potential for further discoveries in the Mesozoic sediments which underlie extensive regions of the Frome Embayment.[151]

3.146 In the Gawler Craton of SA, Minotaur Resources continued exploration drilling of copper-gold-uranium mineralisation at the Prominent Hill deposit. The geological setting and style of mineralisation are similar to Olympic Dam, which is also located in the Gawler Craton 150 km to the southeast. However, uranium grades at Prominent Hill are lower than at Olympic Dam and GA noted that the company has no plans to recover uranium.[152]

3.147 The SA Government Department of Primary Industries and Resources has reported that there are currently more than 20 companies involved in uranium exploration in SA.[153] Media reports have stated that as at January 2006 some 25 Australian and international companies have been granted a total of 86 uranium exploration licenses in SA, an increase of 100 per cent in three years.[154]

3.148 The NTMC also explained that there has recently been considerable interest in uranium exploration in the Territory, with exploration licences granted to 17 companies in the five months to October 2005 alone. There are now some 25 companies currently active in the Territory, with most of these being Australian companies, three Canadian, one UK-linked and one French company, either exploring or planning to explore for uranium.[155] The recent interest in exploration was attributed to the uranium price rise and to the Commonwealth Government's decision to assume responsibility for uranium mine approvals, which gave certainty to the junior companies in the industry. The NTMC estimated that exploration expenditures varied from a couple of hundred thousand dollars by juniors, up to \$5–6 million per year by Cameco, which is the largest explorer in the Territory.[156]

3.149 In terms of exploration activity and expenditure by individual companies, the Committee received the following evidence:

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151 *ibid.*, p. 4.

152 GA, *Exhibit no. 61, loc. cit.*

153 P Abbot, *op. cit.*, p. 1.

154 C Pippos, 'Uranium mines: the rush is on', *Sunday Mail*, 15 January 2006, p. 11.

155 NTMC, *Exhibit no. 75, List of uranium exploration and mining companies working in the Northern Territory as at September 2005.*

156 Ms Kezia Purick (NTMC), *Transcript of Evidence*, 24 October 2005, p. 36.

- Cameco noted that it has been exploring for uranium in Australia for ten years prior to the present price upturn, spending some $50 million in the ARUF of the NT and $4–5 million in the Rudall area of WA to August 2005.[157]
- Heathgate Resources, operators of the Beverley mine, noted that despite the company's small size it is one of the largest explorers for uranium in Australia, with exploration expenditure approximately equal to that of Cameco. Heathgate indicated that it may spend close to $6 million in uranium exploration in 2006.[158]
- Since commencing exploration in Australia, Areva has spent some $150 million with the company focussing on SA but with some exploration also in the NT. Areva argued that there has been negligible uranium exploration over the past twenty years and 'there appears to be a much greater potential for discovery of further uranium resources in Australia.'[159]

3.150 ERA reported that in 2005 the company conducted exploration drilling on the eastern vicinity of the Ranger Pit 3 for the purpose of determining the ultimate size of the orebody. Some 9 232 metres were drilled at a cost of $2.26 million. ERA also conducted airborne geophysical surveys which highlighted further opportunities and exploration drilling may be conducted in 2006.[160]

3.151 RWE NUKEM reported that BHP Billiton plans to spend US$130 million on surface and underground drilling over the next two years to better define the Olympic Dam orebody, as part of its pre-feasibility study for the possible mine expansion. A further US$25 million is budgeted for a new underground tunnel into the southern orebody for detailed resource drilling/technical evaluation.[161]

3.152 In terms of uranium exploration and mine development abroad, Australian mid-tier mining company, Paladin Resources, which owns uranium deposits in WA (Manyingee and Oobagooma), is currently developing a new uranium mine and mill at its Langer Heinrich project in Namibia. Paladin decided to develop the deposit in May 2005. The company is also completing a feasibility study on its Kayelekera Project in Malawi, with the intention of bringing that project into production in 2008 or 2009.[162]

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157 Dr Ron Matthews (Cameco Australia Pty Ltd), *Transcript of Evidence*, 11 August 2005, p. 3.
158 Mr Mark Chalmers, *op. cit.*, p. 97; P Abbot, *loc. cit.*
159 Mr Stephen Mann, *op. cit.*, p. 3.
160 ERA, *2005 Annual Report, op. cit.*, p. 6.
161 RWE NUKEM, *op. cit.*, p. 9.
162 Paladin Resources Ltd, *Submission no. 47*, p. 2; IAEA and OECD-NEA, *op. cit.*, p. 94.

Potential for new discoveries

3.153 The UIC, GA and other submitters argued that:

> The potential for new discoveries is great. Not only have many prospective areas not been explored at all thoroughly, but also geological knowledge evolves and exploration technology improves, so that there is increased sophistication and effectiveness of the exploration effort going into the future. A significant example of this is that in the mid 1970s when the main uranium discoveries were made in Canada's Athabasca Basin, airborne electromagnetic surveys there were effective only to 100 metres depth below the surface, today they yield useful data down to one kilometre. This is particularly relevant to uranium exploration in NT, much of which targets similar geological formations.[163]

3.154 The NTMC concurred with this observation, noting that in the Territory:

> [t]he potential for undiscovered [resources] is high. Only 20 per cent to 25 per cent of the prospective rock units has been effectively explored because superficial cover has masked any potential airborne anomalies.[164]

3.155 In addition to the known undeveloped uranium deposits in the NT (including Jabiluka and Koongarra in West Arnhem Land, and Angela near Alice Springs), there is said to be good uranium mineralisation in the following areas:

> … the Batchelor-Rum Jungle-Coomalie area … 100 kilometres south of Darwin; West Arnhem Land; the Napperby-Tanami-Arunta region, which is about 150 kilometres north-west of Alice Springs; and the Ngalia Basin, 250 kilometres north-west of Alice Springs.[165]

3.156 The NTMC observed that the Alligator Rivers Region is recognised a world class mineral province and unconformity-related uranium deposits are the main exploration target in the NT, because of the potential for large tonnage, low to medium grade resources. However, it was argued that a significant proportion of the most prospective area is included within the boundaries of the Kakadu National Park. Other areas considered prospective for unconformity-related deposits exist in the Ashburton and

163 UIC, *Submission no. 12*, p. 25.

164 NTMC, *Submission no. 51*, p. 6.

165 Ms Kezia Purick, *op. cit.*, p. 33.

Davenport Provinces, Tanami Region and on the margins of the Murphy Inlier.[166] These geological provinces are shown in appendix F.

3.157 Cameco argued that: 'Significant potential remains throughout Australia in a variety of geological provinces and settings', and that the exploration activity 'to date has only relatively scratched the surface.'[167] Cameco mentioned prospective regions that may contain deposits of the following types:

- unconformity-related deposits may be found in the Pine Creek Inlier, particularly the ARUF in West Arnhem Land, in the NT. Other prospective areas for unconformity type mineralisation include the Ashburton and Bresnahan Basins in WA, the Birrindudu Basin in the NT and the Eyre Peninsula of SA.
- Sandstone hosted deposits, which are amenable to ISL mining, may be found in younger basins including the Gunbarrel, Carnarvon and Canning Basins of WA, and the Amadeus and Ngalia Basins of the NT.
- Near surface uranium deposits in very young sediments, which are often hosted in calcrete, may be found in the northern portion of the Yilgarn Craton of WA.[168]

3.158 Southern Gold, which holds exploration tenements in the Gawler Craton of SA, argued that the Gawler contains highly prospective and under-explored geological terrain (relative to the Curnamona/Frome Craton which hosts the Beverley and Honeymoon deposits). It was argued that the Gawler Craton, which hosts the Olympic Dam and Prominent Hill deposits, offers excellent opportunities to discover new shallow resources such as calcrete-hosted deposits amenable to ISL technology.[169]

3.159 GA argued that there is significant potential for additional uranium deposits to be found in Australia, including:

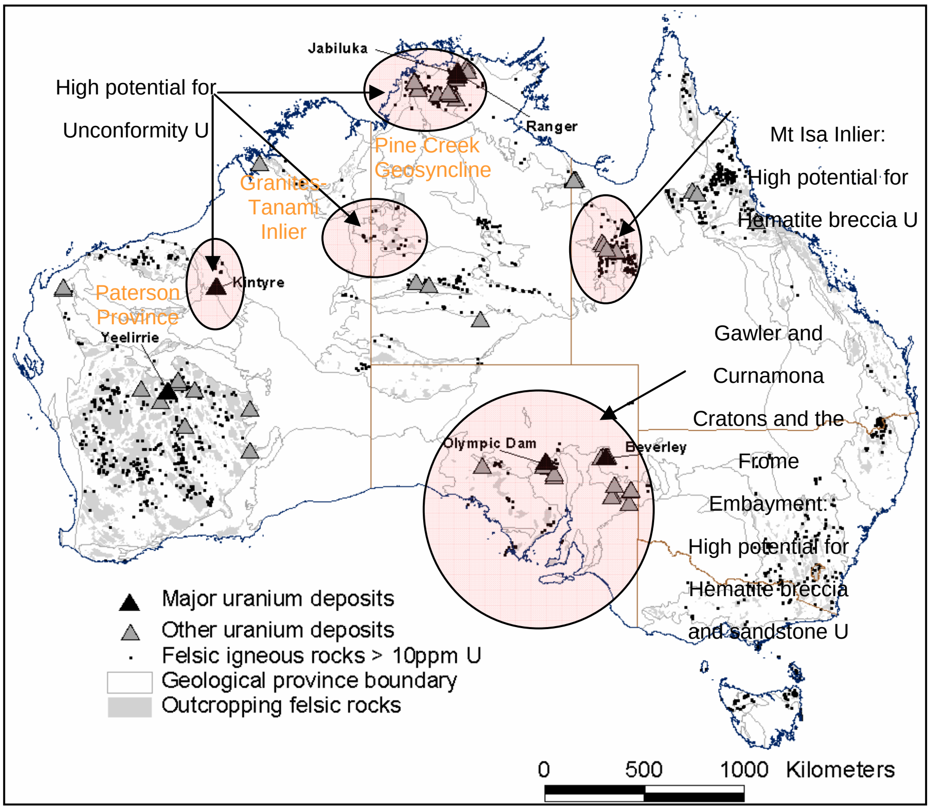
- unconformity-related deposits, including high-grade deposits at and immediately above the unconformity, particularly in Arnhem Land in the NT but also in the Granites–Tanami region (NT–WA), the Paterson Province (WA) and the Gawler Craton (SA);
- hematite breccia deposits, particularly in the Gawler Craton and Curnamona Province of SA, and the Georgetown and Mount Isa Inliers of Qld;
- sandstone-hosted deposits in sedimentary strata in various regions adjacent to uranium-enriched basement; and

166 NTMC, *ibid.*, pp. 5, 6.
167 Cameco Corporation, *loc. cit.*
168 *ibid.*, pp. 5–6.
169 Southern Gold Ltd, *Submission no. 54*, pp. 7, 11, 12.

- carbonatite-related rare earth–uranium deposits in Archaean cratons and Proterozoic orogens.[170]

3.160 GA have identified regions of Australia having a high potential for further discoveries of uranium deposits. These regions are depicted in figure 3.15. GA observed that exploration is currently under way in all these areas, although there has not been much exploration in the Paterson Province in WA to date.[171]

Figure 3.15 Regions of Australia with high potential for uranium



Source Geoscience Australia, *Exhibit no. 60, Australia's uranium resources, production and exploration*, p. 10.

3.161 Cameco and Areva urged that Australia's policy in relation to uranium exploration and mining be clarified. Dr Ron Matthews of Cameco stated that:

> From our perspective, we are here for the long term, but we would like to see clarity on uranium and for Australia's future to be clearly identified. We feel that Australia has significant potential, and that should be harnessed. With the present interest in nuclear

170 I Lambert et. al., *loc. cit.*

171 Mr Aden McKay (GA), *Transcript of Evidence*, *op. cit.*, p. 3.

> energy worldwide, Australia's uranium is a resource that should clearly be developed. We would like to see that moved forward.[172]

3.162 It was submitted that state government opposition to the development of uranium deposits is impeding uranium exploration in those states. Areva observed that:

> Cogema [Areva] believes there is significant potential for uranium discoveries in other states of Australia, but at the moment it prefers to explore in those states that are not opposed to the concept of uranium exploration or mining.[173]

3.163 Likewise, Cameco submitted that 'Cameco Australia's exploration efforts are effectively on hold in WA because of the State government's policy with respect to uranium mining.'[174] It was noted that while a large number of junior companies have recently applied for licenses over prospective ground in WA, 'realistically the level of exploration expenditure will be limited until this policy is changed.'[175]

3.164 Cameco argued that 'without doubt Australia's known resources could be increased', but:

> … there needs to be a significant change in how uranium is viewed and a clear level of support shown at both the Federal and State level. A change in political will and direction is required to give the clear message to companies that it is worthwhile exploring for uranium.[176]

3.165 To this end, the Association of Mining and Exploration Companies (AMEC) recommended that Australia adopt an active exploration program to identify further uranium mineralisation.[177]

The role of junior exploration companies

3.166 During 2004 and 2005, a number of small uranium-focussed exploration companies listed on the Australian Stock Exchange.[178] In 2005, 25 junior exploration companies were exploring for uranium nationwide.[179] While a

172 Dr Ron Matthew, *loc. cit.*

173 Mr Stephen Mann, *loc. cit.*

174 Cameco Corporation, *op. cit.*, p. 5.

175 *ibid.*

176 *ibid.*, p. 6.

177 Mr Alan Layton (AMEC), *Transcript of Evidence*, 23 September 2005, p. 13.

178 GA, *Submission no. 42*, p. 24.

179 Information provided by Mr Aden McKay (GA), 7 July 2006. By July 2006, there were reports of consolidation in the industry, with takeover bids announced for some juniors (particularly from mid-tier Canadian companies). See: J Clarke, 'Uranium players seek out solid ground', *Australian Financial Review*, 8 July 2006, p. 10.

substantial part of the increase in total exploration expenditure in 2005 was due to exploration in the south-east of Olympic Dam, junior companies now account for a significant proportion of total exploration expenditure.[180]

3.167 Several junior companies that submitted to the inquiry mentioned their exploration expenditures:

- Summit Resources, which owns the Valhalla, Skal and Andersons Lode deposits in Qld, reported that it spends between $2.5 and $3 million a year on exploration.[181]
- Compass Resources, which holds tenements at Batchelor (the Rum Jungle uranium field) in the NT, stated that it spent between $20 and $30 million over the past five years exploring for minerals, including uranium.[182]
- Southern Gold, which holds tenements in the Gawler Craton of SA (including the Southern Gawler Arc and Yarlbrinda projects), stated that it aimed to spend $500 000 in 2005 and $1 million per year over the next five years.[183]

3.168 Geoscience Australia observed that a comparison between the exploration expenditures of major mining companies in the early 1990s with those of today reveals that 'what they are spending now is an order of magnitude decrease in general.'[184] Instead, the major companies now:

> … prefer to have good small companies working for them. They can have a loose or somewhat tighter relationship with small companies—maybe seed funding—and then cherry pick the results. That seems to be a model that has emerged.[185]

3.169 Deep Yellow supported this view and argued that:

> The trend over the last 10 years has been for the bigger companies to let the smaller companies do that exploration work, let them take the risk at that early stage and then come in when they have found something. It is a similar case with uranium. It is a risky venture to spend a lot of money on exploration.[186]

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180 Information provided by Mr Aden McKay (GA), 3 February 2006; Areva, *op. cit.*, p. 13.

181 Mr Alan Eggers, *op. cit.*, p. 5.

182 Dr Malcolm Humphreys (Compass Resources NL), *Transcript of Evidence*, 16 September 2005, p. 66.

183 Mr Cedric Horn (Southern Gold Ltd), *Transcript of Evidence*, 19 August 2005, pp. 18–19.

184 Dr Ian Lambert (GA), *Transcript of Evidence*, 5 September 2005, p. 5.

185 *ibid*.

186 Mr James Pratt (Deep Yellow Ltd), *Transcript of Evidence*, 23 September 2005, p. 88.

3.170 Southern Gold emphasised the key role played by juniors following the rationalisation of the mining industry and the retreat of large companies from exploration activity. It was argued that because juniors are now 'carrying a greater burden for defining and developing Australia's uranium resources but with limited funding', these smaller companies merit support from government:

> The junior exploration sector warrants expanded financial and regulatory support from State and Federal governments in facilitating exploration for the country's future development, competitiveness and prosperity.[187]

3.171 Among other recommendations, Southern Gold called for the provision of high quality geoscientific data and encouragement for industry through programs such as the PACE initiative ('Plan for Accelerating Exploration') in SA, where 'the (State) government subsidises drilling programs dollar for dollar.'[188] The company also recommended subsidies for infrastructure development in regional areas.[189]

3.172 The MCA agreed that there has been structural adjustment in the minerals industry. A consequence of the rationalisation and consolidation of the industry is that now 'much of the exploration effort is essentially outsourced to junior companies.'[190] For the MCA, the significant role of juniors in conducting much of the uranium exploration points to the importance of:

> … one of the … fundamental platforms of the exploration action agenda, which is flow-through shares and improved financing or being able to wash out the tax liabilities to investors. The juniors do not have income to offset these tax liabilities, so there is a market failure in terms of tax asymmetry.[191]

3.173 The Committee notes that its previous report, *Exploring: Australia's Future*, recommended that the Australian Government examine the introduction of a flow-through share scheme for companies conducting eligible minerals and petroleum exploration activities in Australia.[192] The Committee also notes that the 2005 progress report on the implementation

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187 Southern Gold Ltd, *op. cit.*, p. 2.

188 Mr Cedric Horn, *op. cit.*, p. 15. See: Primary Industries and Resources SA, *PACE – A Plan for Accelerating Exploration*, Government of SA,, viewed 6 July 2006, <http://www.pir.sa.gov.au/byteserve/minerals/initiatives/pdf/pace_brochure_web.pdf>.

189 Southern Gold Ltd, Submission no. 54.1, 5–6.

190 Mr Mitch Hooke (MCA), *Transcript of Evidence*, 5 September 2005, p. 35.

191 *ibid*.

192 House of Representatives Standing Committee on Industry and Resources (HRSCIR), *Exploring: Australia's Future*, Commonwealth of Australia, Canberra, 2003, p. 40. Available online: <http://www.aph.gov.au/house/committee/isr/resexp/chapter3.pdf>.

of recommendations from the Minerals Exploration Action Agenda (MEAA) strongly advocated the introduction of a flow-through share system to 'reinvigorate the search for the next generation of Australia's mineral deposits.'[193]

3.174 The NTMC expressed strong support for a close examination of a flow-through share scheme, 'to try and drive exploration expenditure in Australia, which has lost ground significantly compared to the rest of the world.'[194] Dr Ron Matthews of the NTMC argued that:

> I would see great benefits in that to drive greenfields exploration in particular, and also to benefit junior companies specifically, which really form the engine behind the resource industry. I think there is a move to look at that; I think we would all endorse this being looked at very seriously.[195]

3.175 In its previous report, which addressed impediments to exploration, the Committee accepted that future world-class uranium deposits are likely to be located at greater depths than those hitherto discovered. It was concluded that this will require large injections of exploration investment capital to overcome the technical challenges of locating bedrock deposits. These observations reinforce the need to ensure that juniors, which are generally efficient explorers, are appropriately assisted to discover Australia's future world-class uranium and other mineral deposits. The Committee is convinced of the merits of flow-through share schemes and repeats the recommendation contained in its previous report. The Committee makes additional observations about the challenges faced by junior companies in chapter 11.

Recommendation 1

The Committee recommends that the Australian Government introduce a flow-through share scheme for companies conducting eligible minerals and petroleum exploration activities in Australia.

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193 MEAA Implementation Group, Notes from the Chair, *Annual Progress Report to the Minister for Industry, Tourism and Resources*, DITR, Canberra, November 2005, viewed 24 March 2006, <http://innovation.gov.au/assets/documents/itrinternet/MEAA_Implementation_Group_2005_Annual_Report20051122124132.pdf>.

194 Dr Ron Matthews (NTMC), *Transcript of Evidence*, 24 October 2005, p. 37.

195 *ibid*.

New exploration technologies and geoscientific data

3.176 The Committee's previous report observed that future exploration programs aimed at major discoveries beneath thick cover are likely to require high-cost sophisticated exploration technology.[196]

3.177 Evidence presented to the Committee's current inquiry again pointed to the need for new technologies to identify deposits located at depth. For example, GA emphasised the need for a new generation of tools and technologies to assist in the discovery of uranium deposits located down to 500 metres below surface:

> … the focus has to be on the covered areas like the Gawler Craton where you have deep weathering and sedimentary cover. The information available for those covered areas is limited … We need a new generation of information … we have to look through the cover and get down to the rocks of 100 to 400 or 500 metres below the surface. We need to bring in a new set of technologies to do that. It is important to be able to identify palaeochannels in the Frome Embayment and to be able to identify the favourable alteration minerals in the Olympic Dam domain for that style of mineralisation. That requires a new generation. That is what we hope will eventually come to GA as a result of the various inquiries we have had in the last couple of years.[197]

3.178 Cameco argued that: 'The potential for new discoveries, in both previously defined terrains and new areas, using advanced techniques and deep exploration tools is very high.'[198] Similarly, the MCA argued that:

> Australia's current Economic Demonstrated Resources, though large, underestimates the potential resource. Indeed, given that exploration technology has improved significantly in recent years, there is a reasonable expectation that significantly more uranium would be discovered if the latest technologies and models of how ore bodies form were applied in Australia.[199]

3.179 CSIRO explained that future discoveries of uranium will require more sophisticated geochemical and geophysical technologies in order to see through the regolith to discover the deeper deposits.[200]

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196 HRSCIR, *op. cit.*, pp. 47, 61–62.

197 Dr Ian Lambert, *op. cit.*, p. 5. See also: Mr Keith Alder, *Transcript of Evidence*, 16 September 2005, p. 81.

198 Cameco Corporation, *op. cit.*, pp. 4–5. See also: UIC, *Submission no. 12*, p. 25.

199 MCA, *op. cit.*, p. 4.

200 Dr Rod Hill (CSIRO), *Transcript of Evidence*, 19 August 2005, p. 6.

3.180 In terms of particular techniques to provide the needed precompetitive geoscience, GA mentioned that regional airborne electromagnetics could be more widely deployed to identify minerals and the graphite related to uranium hundreds of metres below surface.[201]

3.181 GA also informed the Committee that the Athabasca Basin in Canada, which contains several extremely high-grade deposits (such as Macarthur River and Cigar Lake), has been exhaustively surveyed in a collaborative study involving the Geological Survey of Canada and mining companies using these techniques:

> They have pulled it apart and done everything they possibly could to it—the sorts of things that we do here in Australia, depending on our level of resources. They have done seismic studies, airborne geophysical studies and a whole lot of pulling together of existing information. That has shown a number of areas of potential in that highly prospective Athabasca Basin.[202]

3.182 The MCA supported GA's call for the deployment of more sophisticated techniques to improve the under cover exploration activity. The MCA noted that a recommendation for additional funding for precompetitive geoscientific data was one of the four elements of the MEAA.[203] It was also noted that the use of exploration techniques that are classed as 'low impact' permit expedited approvals procedures under the Native Title Act. The MCA urged the Committee to 'back the increased resourcing for precompetitive geoscientific data for Geoscience Australia.'[204] The MCA stated that it:

> … strongly supports the Minerals Exploration Action Agenda proposal of a new, national innovative geoscience program to underpin the discovery of the next generation of ore deposits in frontier areas to sustain Australia's mineral exports.[205]

3.183 The NTMC argued that the provision of geoscience data by the NT Government is 'extraordinary and it is very highly regarded by industry.'[206] Nonetheless, the NTMC also argued that the Territory and

201 Dr Ian Lambert, *op. cit.*, p. 9.

202 *ibid.*, p. 7.

203 The four key areas are: access to finance; the quality and availability of pre-competitive geoscience information; access to land; and access to human and intellectual capital. See: DITR, *Minerals Exploration Action Agenda*, viewed 7 July 2006, <www.industry.gov.au/minexpagenda>.

204 Mr Mitch Hooke, *op. cit.*, p. 35.

205 MCA, *op. cit.*, p. 3.

206 Ms Kezia Purick, *op. cit.*, p. 43.

Commonwealth Governments should work together to encourage the search for new deposits.[207]

3.184 Jindalee Resources and Southern Gold also spoke highly of the survey data provided by the NT Government and GA:

> It is sensational. It is great stuff. The state governments will now give you all of their geophysical surveys on disk. You can get them for just about nothing. The Northern Territory government is sensational with that. Instead of repeating the work that somebody else did five years ago you can get all of this on file now.[208]

3.185 In its previous report on the impediments to increasing Australia's exploration investment, the Committee made several recommendations pertaining to precompetitive geoscientific data, including that the Australian Government provide additional funds to enable GA to accelerate data acquisition programs.[209]

3.186 The Committee notes that in the 2005 progress report on the implementation of recommendations from the MEAA, the implementation group also recommended that:

> … a new national geoscience program should be implemented to address the deficiencies in modern coverage. A new program should specifically focus on pioneering new techniques and methods for revealing the potential of Australia's prospectivity under sedimentary cover, and at depth.[210]

3.187 The MEAA implementation group repeated the recommendation that new precompetitive geoscience information, particularly geophysical data, be provided for frontier areas.

3.188 The Committee welcomes the announcement in August 2006 of an addition $59 million for GA to pioneer the application of innovative, integrated geoscientific research designed to identify on-shore energy sources. Nonetheless, the Committee calls for additional funding for GA to develop and deploy new techniques to assist in the discovery of new world-class uranium deposits.

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207 *ibid.*, p. 33.

208 Mr Donald Kennedy (Jindalee Resources Ltd), *Transcript of Evidence*, 23 September 2005, p. 67; Mr Cedric Horn, *op. cit.*, pp. 21, 22.

209 HRSCIR, *op. cit.*, p. 55.

210 MEAA Implementation Group, *Annual Progress Report to the Minister for Industry, Tourism and Resources*, DITR, Canberra, November 2005, p. 15, viewed 24 March 2006, <http://innovation.gov.au/assets/documents/itrinternet/MEAA_Implementation_Group_2005_Annual_Report20051122124132.pdf>.

Recommendation 2

The Committee recommends that Geoscience Australia be granted additional funding to develop and deploy new techniques, including airborne electromagnetics, to provide precompetitive geoscience of prospective areas, in order to assist in the discovery of new world-class uranium and other mineral deposits located under cover and at depth.

Conclusions

3.189 The Committee was pleased to note record uranium production and exports for Australia in calendar year 2005. Production across the three operational mines (Ranger, Olympic Dam and Beverley) was 11 222 t U_3O_8 and exports were 12 360 t U_3O_8. Uranium exports also earned a record $573 million in 2005.

3.190 Australia is rightly regarded as a low-cost and reliable supplier of uranium. The Committee agrees that there is great potential for Australia to expand production and become the world's premier supplier of uranium. Specifically, the Committee looks forward with interest to the outcomes of BHP Billiton's PFS and feasibility studies for the possible expansion of Olympic Dam. Should the proposed expansion proceed, Olympic Dam could be producing some 20 per cent of world uranium mine output by 2013. If this were to eventuate, national production would be double the current level and Australia would become by far the world's largest uranium producer. The Committee would welcome this development.

3.191 In addition, the Committee notes that sxr Uranium One, owners of the Honeymoon deposit in SA which has already been granted a mining lease and an export license, have announced that the company expects to proceed with construction in the second half of 2006. Australia's second ISL mining operation is expected to commence production in 2008.

3.192 Although the Committee appreciates that ISL mining is applicable in very specific geological conditions, it notes that this mining method has numerous advantages over traditional excavation techniques, including minimal environmental impacts. The Committee was extremely impressed with the Beverley operation, its minimal surface disturbance and its advanced instrumentation. Committee members were convinced that once production has ceased at Beverley and the infrastructure has been removed, there will be virtually no indication that a mine ever existed at the site at all and the rehabilitation process will be relatively simple.

3.193 The Committee was also pleased to note Heathgate Resources' claim that Beverley is not only the largest but also the most technologically advanced ISL operation in the world. The Committee hopes that the Australian uranium industry will continue to lead the world in this area of expertise.

3.194 The Committee notes that Australia possesses 36 per cent of the world's RAR of uranium recoverable at low cost and 43 per cent of the world's low cost Inferred Resources. Australia has some 85 uranium deposits scattered across the country and these contain a total of over 2 Mt U_3O_8. Australia also possesses the world's largest quantity of thorium resources, which could be used as nuclear fuel.

3.195 Almost all of Australia's Identified Resources of uranium are contained in six deposits—Olympic Dam, Ranger Jabiluka, Koongarra, Kintyre and Yeelirrie. Olympic Dam, the world's largest uranium orebody, dwarfs all others and contains an estimated overall resource of 1.46 Mt of U_3O_8. Olympic Dam contains 26 per cent of the world's entire RAR recoverable at low cost.

3.196 The Committee notes that improvements in the recoveries of uranium from brannerite mineralisation, which have the potential to significantly increase Australia's recoverable resources (mainly at Olympic Dam and the Mt Isa deposits) would, in turn, have important ramifications for Australia's uranium mining industry. Given its importance for the industry as a whole, the Committee encourages an increased research and development effort to achieve improved uranium recoveries.

3.197 Notwithstanding the size of Australia's resources, the Committee notes that some 10 per cent of Australia's low cost uranium resources are deemed inaccessible to mining. Aside from those deposits in the NT that are surrounded by the Kakadu National Park, these resources include the deposits that cannot be developed in WA and Qld due to state government prohibitions on uranium mining. State government restrictions have also impeded exploration investment and activity in these states as mining companies have gone elsewhere to explore.

3.198 While there has been a trend of increasing exploration expenditures since 2003, there was relatively little exploration for uranium over the previous two decades and Australia's known uranium resources generally reflect exploration efforts that took place 30 years ago. As exploration expenditures declined from 1980 onwards, only four new uranium deposits were found and only one, Kintyre in WA, contains RAR recoverable at low cost. It follows that the size of Australia's known uranium resources significantly understates the potential resource base.

3.199 The Committee concludes that there are a number of regions that are highly prospective for uranium and there is great potential for new discoveries in various geological settings across Western Australia, South Australia, the Northern Territory and Queensland. Regrettably, there has been no exploration for uranium in Victoria and NSW since these states legislated to prohibit uranium mining in the 1980s.

3.200 Reflecting a trend which is occurring across the minerals industry, junior companies are now conducting much of the exploration activity for uranium. With the withdrawal of major mining companies, there are now calls for increased government support for juniors. The Committee repeats the recommendation contained in its previous report that a flow-through share scheme for companies conducting eligible minerals exploration activities in Australia be introduced.

3.201 The Committee is aware that there has been a significant turn-around in uranium exploration expenditure in recent years and a key obstacle to further uranium exploration is opposition to uranium mining in some states. Other impediments to juniors are discussed in chapter 11.

3.202 Submitters pointed to the need for a new national geoscience program to address current deficiencies. It was argued that future discoveries of uranium will require more sophisticated geochemical and geophysical technologies in order to see through the regolith to discover the deeper deposits. The Committee recommends that GA be funded to develop and deploy techniques to provide precompetitive geoscience of prospective areas, in order to assist in the discovery of new uranium (and other mineral) deposits located at depth.

3.203 In the following chapter, the Committee considers the potential implications for global greenhouse gas emission reductions from the further development and export of Australia's uranium resources.

4

Greenhouse gas emissions and nuclear power

Responsible and balanced policy would strive for a mix of low-greenhouse energy sources: CO2-free nuclear for baseload power in countries with high ambient power demand; low-CO2 coal, because coal is abundant; natural gas for peaking loads; hydro, wind, tidal, solar where suitable and appropriate. Achieving better energy efficiency in product design and use and reducing excessive consumption in the developed world through better electricity pricing are also important strategies. There is no single panacea, but no likely remedy should be arbitrarily rejected. Windmills and reactors each have parts to play.[1]

… I am a Green and I entreat my friends in the movement to drop their wrongheaded objection to nuclear energy. Even if they were right about its dangers, and they are not, its worldwide use as our main source of energy would pose an insignificant threat compared with the dangers of intolerable and lethal heat waves and sea levels rising to drown every costal city in the world. … civilisation is in imminent danger and has to use nuclear – the one safe, available, energy source – now or suffer the pain soon to be inflicted by our outraged planet.[2]

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1 Paladin Resources Ltd, *Submission no. 47*, p. 7.

2 Sir James Lovelock, 'Nuclear Power is the only green solution', *The Independent*, 24 May 2004, viewed 15 May 2006, <http://comment.independent.co.uk/commentators/article61727.ece>.

Key messages —

- **Electricity generation is the largest and fastest growing contributor to global carbon dioxide (CO_2) emissions, responsible for 40 per cent of global emissions in 2003—10 billion tonnes of CO_2. Emissions from electricity are projected to contribute approximately 50 per cent of the increase in global CO_2 emissions to 2030.**
- **Nuclear power is a CO_2-free energy source at point of generation.**
- **Over the whole fuel cycle, nuclear power emits only 2–6 grams of carbon (or up to 20 grams of CO_2) per kilowatt-hour of electricity produced. This is two orders of magnitude less than coal, oil and natural gas, and is comparable to emissions from wind and solar power.**
- **A single nuclear power plant of one gigawatt capacity offsets the emission of some 7–8 million tonnes of CO_2 each year if it displaces coal. A nuclear plant will also offset the emission of sulphur dioxide, nitrous oxide and particulates, thereby contributing significantly to air quality.**
- **Nuclear power currently avoids the emission of 600 million tonnes of carbon per year. If the world were not using nuclear power, CO_2 emissions from electricity generation would be at least 17 per cent higher and 8 per cent higher for the energy sector overall. By 2030, the cumulative carbon emissions saved due to the use of nuclear power could exceed 25 billion tonnes.**
- **Australia's uranium exports currently displace at least 395 million tonnes of CO_2 per year, relative to use of black coal. This is equivalent to 70 per cent of Australia's total greenhouse gas emissions for 2003. Australia's total low cost uranium reserves could displace nearly 40 000 million tonnes of CO_2 if it replaced black coal electricity generation.**
- **The capacity of uranium to mitigate production of greenhouse gases depends on the extent to which nuclear power displaces carbon-based energy sources in electricity generation. In the future, nuclear power may also have the capacity to reduce emissions from the transport sector through the production of hydrogen.**
- **For the generation of continuous, reliable supplies of electricity on a large scale, the only alternative to fossil fuels is nuclear power.**
- **Nuclear power is cost competitive with gas and coal-fired electricity generation in many industrialised countries. Nuclear plants offer**

very low operating costs, security of energy supply and electricity price stability.

Introduction

4.1 This chapter addresses the greenhouse gas emissions avoided by the use of nuclear power, emissions across the whole nuclear fuel cycle, the contribution from renewable energy sources, and the relative economic attractiveness of nuclear power for baseload power generation.

4.2 In turn, the Committee considers:

- the nature of the enhanced greenhouse effect and the potential consequences of climate change;
- projections for global energy and electricity demand and associated carbon dioxide emissions; and
- the contribution that nuclear power makes to the mitigation of greenhouse gas emissions, the quantity of emissions displaced by export of Australia's uranium, and the possible future emission savings from expanded use of nuclear power.

4.3 The Committee then considers arguments critical of nuclear's greenhouse gas mitigation potential, including claims about emissions across the whole nuclear fuel cycle compared to other electricity generation chains, the energy used to enrich uranium and the energy required to extract uranium as ore grades decline. The Committee then addresses arguments associated with the claim that nuclear power is too limited, slow and impractical to 'solve' climate change. Discussion follows on the limitations of renewables and efficiency measures, and the need for a mix of low-emission energy sources.

4.4 The chapter concludes with an overview of the economics of nuclear power and its competitiveness relative to other baseload alternatives and renewables.

The enhanced greenhouse effect

4.5 The greenhouse effect is the term used to describe the retention of heat in the Earth's lower atmosphere. The enhanced greenhouse effect refers to the rise in the Earth's surface temperature (global warming) which is considered likely to occur because of the increasing concentration of certain gases in the atmosphere due to human activities. These gases are referred to as greenhouse gases.[3]

4.6 Greenhouse gases absorb infrared radiation reflected back from the Earth's surface and trap heat in the atmosphere. The principal greenhouse gases are carbon dioxide (CO_2), methane, halocarbons and nitrous oxide. While some greenhouse gases exist in nature, such as water vapour, CO_2 and methane, others are exclusively human-made, such as gases used for aerosols.

4.7 Atmospheric concentrations of greenhouse gases have increased significantly during the last century and most of this increase is attributed to human sources; that is, of anthropogenic origin. Human activities that generate greenhouse gases include burning fossil fuels (coal, oil and natural gas), agriculture and land clearing.[4]

4.8 Carbon dioxide is considered the most significant anthropogenic greenhouse gas (GHG) and fossil fuel combustion is known to be responsible for the largest share of global anthropogenic GHG emissions, accounting for 80 per cent of emissions in industrialised countries in 2003. The second largest source of GHG emissions is agriculture, which contributes seven per cent (mainly methane and nitrous oxide).[5]

4.9 The atmospheric concentration of CO_2 is now at 380 part per million by volume (ppmv), which is the highest level for at least 420 000 years, and possibly the highest concentration for 20 million years.[6]

4.10 In addition to historically high concentrations, the rate of increase is also unprecedented during at least the past 20 000 years.[7] Evidence emphasised that 'of the non-catastrophic sources of quick CO_2 emissions into the atmosphere, it appears that the rate of change in the last 150 years has been greater than that previously witnessed.'[8] That is, although major volcanic events such as Krakatoa have introduced large volumes of CO_2 into the atmosphere in shorter time frames, the current rise is the fastest increase of anthropogenic origin.

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3 Uranium Information Centre (UIC), *Global Warming*, Nuclear Issues Briefing Papers No. 24, UIC, Melbourne, 2003, viewed 11 May 2006, < http://www.uic.com.au/nip24.htm>.

4 Australian Greenhouse Office (AGO), *Climate Change Science – Questions Answered*, Australian Government Department of the Environment and Heritage, Canberra, 2005, p. 5, viewed 12 January 2006, <http://www.greenhouse.gov.au/science/qa/index.html>.

5 International Energy Agency (IEA), *CO_2 Emissions from Fossil Fuel Combustion 1971–2003*, OECD/IEA, Paris, 2005, p. xvii.

6 B Pittock (ed), *Climate Change: An Australian Guide to the Science and Potential Impacts*, AGO, Canberra, 2003, p. 23.

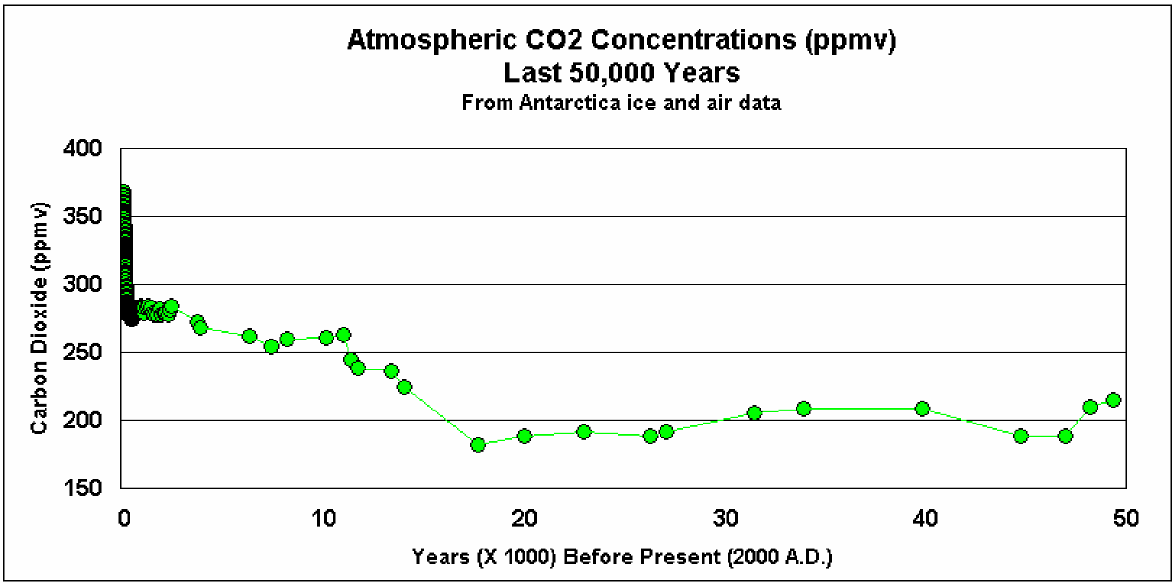
7 Nova Energy Ltd, *Submission no. 50*, p. 18.

8 Dr Rod Hill (CSIRO), *Transcript of Evidence*, 19 August 2005, p. 8.

4.11 The increase in atmospheric concentrations of CO_2 during the past 250 years is depicted in figure 4.1. Over the period from 50 000 years ago to the last hundred years, concentrations remained in the range of 200 to 270 ppmv. However, the Australian Nuclear Science and Technology Organisation (ANSTO) argued that since the industrial revolution CO_2 concentrations have increased dramatically.[9] In 1750, CO_2 concentrations were approximately 280 ppmv, but by 2000 they had risen to 370 ppmv—an increase of 32 per cent.[10]

4.12 The rate of increase has been pronounced even over the span of a few decades. In 1959, CO_2 concentrations were 316 ppmv, but had risen to 375 ppmv by 2003—an 18.8 per cent increase over just 44 years.[11]

Figure 4.1 Atmospheric concentrations of CO_2 over the last 50 000 years (parts per million by volume)



Source ANSTO, *Exhibit no. 74, Presentation by Dr Ron Cameron and Dr Ian Smith*, p. 17.

4.13 The Committee's inquiry was concerned with the potential implications for global GHG emission reductions from the further development of Australia's uranium resources. Comment was not explicitly sought on the link between GHG emissions and global warming, or the possible severity of climate change. Nevertheless, most submitters were convinced that 'carbon dioxide is driving … global climate change. The greenhouse effect

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9 Dr Ian Smith (ANSTO), *Transcript of Evidence*, 13 October 2005, p. 5.

10 Dr Michael Goldsworthy (Silex Systems Ltd), *Transcript of Evidence*, 9 February 2006, p. 2. In addition, nitrous oxide levels have increased by 17 per cent and methane concentrations have more than doubled. See also: AGO, *op. cit.*, p. 6.

11 Nova Energy Ltd, *loc. cit.*

is real' and global warming will have 'potentially catastrophic consequences.'[12]

4.14 Drawing on findings published by the International Panel on Climate Change (IPCC), it is widely reported that the global average surface temperature increased by about 0.6 degrees Celsius (°C) over the past one hundred years (0.7°C in Australia).[13] Carbon dioxide is estimated to contribute some 60 per cent of the warming effect.[14]

4.15 In its Third Assessment Report (2001), the IPCC concluded that 'there is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities.'[15] According to all IPCC emissions scenarios, CO_2 concentrations, global average temperature and sea-level rise are all projected to increase in the coming decades without additional mitigation action.

4.16 ANSTO commented that the world cycles between glacial and warmer inter-glacial periods over about 100 000 years. During each cycle, sea level changes by about 120 metres and the temperature changes by approximately five or six degrees. A change in cycle is thought to be triggered by about 180 ppmv CO_2 to 260 ppmv CO_2. As noted above, atmospheric concentrations are now at about 380 ppmv and are projected to rise to at least 450 or even 550 ppmv. ANSTO argued that:

> … the world is now into a cycle that has been going on for a period of 150 years. We are making the kinds of change in CO_2 level that triggered that change happening in just 100-odd years.[16]

That is, climatic changes that would previously have been experienced over a 100 000 year glacial-interglacial cycle are projected to occur in a mere 100 years.

4.17 In addition to global temperature change and sea level rise, ANSTO noted that increased CO_2 concentrations acidify the oceans which will have potentially disastrous effects on coral reefs and marine life.[17]

4.18 The potential consequences of global warming were emphasised by the Chief Scientific Adviser to the British Government, Sir David King, who attributed half of the severity of the 2003 heatwave in Europe, which killed 30 000 people, to global warming with a 90 per cent statistical certainty.[18]

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12 Dr Michael Goldsworthy, *loc. cit*; Nova Energy Ltd, *op. cit.*, p. 19.

13 B Pittock, *op. cit.*, p. 3; AGO, *op. cit.*, p. 4.

14 UIC, *loc. cit.*

15 Cited in IEA, *op. cit.*, p. xviii.

16 Dr Ian Smith, *op. cit.*, p. 6.

17 *ibid.*

18 *ibid.*

4.19 While the Committee notes that there are uncertainties in the science of climate change, the Australian Government reports that climate models, based on a range of emission scenarios, indicate that increasing atmospheric concentrations of greenhouse gases could cause average global temperatures to rise by between 1.4 and 5.8°C by 2100.[19] The consequences of a temperature rise of this magnitude could be dramatic:

> This rate and magnitude of warming are significant in the context of the past 400,000 years. History has shown us that a warming of 1–2°C can have dramatic consequences. Even the 0.6°C warming in the past 100 years has been associated with increasing heat waves and floods, fewer frosts, more intense droughts, retreat of glaciers and ice sheets, coral bleaching and shifts in ecosystems. A further warming of 1.4 to 5.8°C could challenge the adaptive capacity of a range of human and natural systems.[20]

The global energy situation and carbon dioxide emissions

4.20 Global primary energy demand is projected to grow at a rate of 1.6 per cent per year in the period 2003 to 2030. This would see demand for energy increase by 52 per cent over the period and reach 16.3 billion tonnes of oil equivalent (toe) by 2030.[21]

4.21 Fossil fuels are expected to continue to meet the overwhelming bulk of the world's energy needs. Oil, natural gas and coal are expected to account for 83 per cent of the increase in world energy demand over 2003–30 and account for 81 per cent of energy demand in 2030 (up slightly from 80 per cent in 2003).[22]

4.22 Electricity consumption, which uses some 40 per cent of the world's primary energy supply, is forecast to grow at a faster rate than overall energy demand. Electricity consumption is projected to grow at an annual rate of 2.5 per cent and rise from 15 000 terawatt-hours (TWh) currently, to

19 AGO, *op. cit.*, p. 5; Nova Energy, *op. cit.*, p. 19. Media reports claim that the IPCC's Fourth Assessment Report, to be issued in 2007, will find that temperature rises will be between 2 and 4.5°C by 2100. See: M Warren, 'Science tempers fears on climate', *The Australian*, 2–3 September 2006, p. 1.

20 AGO, *loc. cit.*

21 IEA, *World Energy Outlook 2005*, OECD/IEA, Paris, 2005, p. 80.

22 *ibid.*; ANSTO, *Exhibit no. 74, Presentation by Dr Ron Cameron and Dr Ian Smith,* p. 26.

24 000 TWh by 2025.[23] The growth in demand is likely to be driven by the industrial modernisation of India and China.[24]

4.23 In 2003, fuel for world electricity production was provided 39.9 per cent by coal, 19.2 per cent by natural gas, 6.9 per cent by oil (for a total of 66 percent from burning fossil fuels), 16.3 per cent by hydro, 1.2 per cent by combustible renewables (such as biomass), and 0.7 per cent from geothermal, solar and wind combined. Nuclear was the fourth largest fuel source for electricity generation at 15.7 per cent.[25] It is anticipated that the majority of the growth in electricity consumption will be fuelled by coal.[26]

4.24 World CO_2 emissions from fossil fuel combustion reached 25 billion tonnes (gigatonnes, Gt) in 2003, an increase of 20 per cent on the 1990 level of 20.7 Gt. Of these emissions, around 38 per cent comes from coal, 21 per cent from gas and 41 per cent from oil.[27] Energy-related CO_2 emissions are projected to increase by 1.6 per cent annually between 2003 and 2030, reaching 37 Gt of CO_2 emitted annually by 2030—an increase of 52 per cent over the 2003 level.[28]

4.25 According to the IEA, the largest and fastest growing contributor to global CO_2 emissions is the electricity and heat sector, which contributed 40 per cent of world CO_2 emissions in 2003—10 Gt of CO_2. Emissions from electricity generation grew by 44 per cent over the 13 years to 2003 and are projected to contribute approximately 50 per cent of the increase in global emissions to 2030. Other major contributors to world CO_2 emissions are the transport sector (24 per cent) and manufacturing and construction (18 per cent). Transport will contribute a quarter of the emissions increase to 2030.[29]

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23 IEA, *Electricity Information 2005*, OECD/IEA, Paris, 2005, p. I.4; UIC, *Submission no. 12*, p. 7; Summit Resources Ltd, *Submission no. 15*, p. 27; Heathgate Resources Pty Ltd, *Exhibit no. 57, Energy for the World – Why uranium?,* p. 2.

24 Dr Michael Goldsworthy (Silex Systems Ltd), *Transcript of Evidence*, 9 February 2006, p. 2; UIC, *loc. cit*.

25 IEA, *Electricity Information 2005*, *op. cit*., pp. I.39, I.43. See also: World Nuclear Association (WNA), *Sustainable Energy – Uranium, electricity and greenhouse*, March 2006, viewed 16 March 2006, <http://world-nuclear.org/education/ueg.htm>; Cameco Corporation, *Submission no. 43*, p. 6; Mr Bernie Delaney (BHP Billiton Ltd), *Transcript of Evidence*, 2 November 2005, p. 26.

26 Dr Michael Goldsworthy, *loc. cit*. Association of Mining and Exploration Companies (AMEC), *Submission no. 20*, p. 7.

27 WNA, *Sustainable Energy – Uranium, electricity, and greenhouse*, March 2006, viewed 16 May 2006, <http://world-nuclear.org/education/ueg.htm>.

28 IEA, *CO_2 Emissions from Fossil Fuel Combustion 1971–2003, op. cit*., p. xxiii; IEA, *World Energy Outlook 2005*, *op. cit*., p. 92.

29 IEA, *CO_2 Emissions from Fossil Fuel Combustion 1971–2003*, *op. cit.,* pp. xxiii, xxviii; IEA, *World Energy Outlook 2005, loc. cit.*

4.26 While industrialised countries have been overwhelmingly responsible for the build-up in fossil fuel-related CO_2 concentrations to date, much of the future increase in emissions is expected to occur in the developing world, where economic development and energy demand is predicted to be supplied primarily with fossil fuels. Developing countries' emissions are expected to grow above the world average at 2.7 per cent annually to 2030. Developing countries will be responsible for 73 per cent of the increase in global CO_2 emissions to 2030 and surpass the OECD as the leading contributor to global emissions in the early 2020s. The increase in emissions from China alone will exceed the increase in all OECD countries and Russia combined.[30]

4.27 ANSTO amplified the significance of the forecast growth in energy demand in developing countries, explaining that during the last 30 years some 31 per cent of the growth in energy production was in the OECD, with 59 per cent in the developing world. In the next 30 years however, there is predicted to be only three per cent growth in the OECD, but 85 per cent growth in the developing countries:

> If you take Nigeria, for instance, the average electricity consumption per person is 70 kilowatt hours per year. If you want to quantify it, that is the equivalent of leaving your television set on stand-by for the year. The average use in Europe is 8,000 kilowatt hours per person. So as these people develop, we are going to have a greater energy demand.[31]

4.28 The IEA also notes that in 2003 some 1.6 billion people were without access to electricity. If future energy demand is met by fossil fuels, the implications for CO_2 emissions are dramatic, as indicated in the forecasts above.[32]

4.29 With these forecasts in mind, a number of submitters argued that nuclear power will be essential to reduce emissions from electricity generation. For example, Cameco argued that:

> Numerous studies have noted the generation of electricity from fossil fuels, notably coal and natural gas, is a major and growing contributor to the emissions of carbon dioxide – a greenhouse gas that contributes significantly to global warming. There is a scientific consensus that these emissions must be reduced, and a growing opinion the increased use of nuclear power is one of only

30 ANSTO, *Exhibit no. 74, Presentation by Dr Ron Cameron and Dr Ian Smith*, p. 28; IEA, *World Energy Outlook 2005, op. cit.*, pp. 92, 93.

31 Dr Ian Smith, *op. cit.*, p. 7.

32 IEA, *CO_2 Emissions from Fossil Fuel Combustion 1971–2003*, *op. cit.*, p. xvii.

a few realistic options for reducing carbon dioxide emissions from electricity generation.[33]

4.30 Similarly, Areva argued that stabilising emissions will require mitigation policies. It was noted that in order to stabilise emissions at a target of 550 ppm of CO_2 will require that emissions be limited to 10 billion tonnes of carbon (GtC) per year by 2050. Achieving this target will require avoiding about 6 GtC per year from the current trend by 2050 and even more after that. Areva argued that human adaptation systems to climate change will need to be developed but that this capacity is limited, particularly in developing countries: 'We thus need to implement mitigation policies to avoid unbearable costs for economies.'[34]

4.31 The Committee now turns to a consideration of the GHG emissions from use of nuclear power and the extent to which nuclear power mitigates emissions from other sources.

Nuclear power's contribution to greenhouse gas mitigation

4.32 Most submitters to the inquiry who expressed a view on this issue argued that the use of nuclear power reduces GHG emissions and that 'the export of uranium helps reduce greenhouse emissions in other countries to the extent that nuclear power produced replaces higher emission sources.'[35] A sample of the observations made on this issue follows:

- 'Realistic assessment shows that nuclear energy is indispensable in abating the intensification of greenhouse gases resulting from the inexorable rise of global energy consumption.'[36]
- 'There is incontrovertible evidence that from an emission standpoint uranium is a clean fuel.'[37]

33 Cameco Corporation, *op. cit.*, p. 7.

34 Areva, *Submission no. 39*, p. 4.

35 Minerals Council of Australia (MCA), *Submission no. 36*, p. 10. See also: ANSTO, *Submission no. 29*, p. 8. Some 30 submitters expressed this view. See for example: Mr Robert Elliott, *Submission no. 1*, p. 1; Mr John Reynolds, *Submission no. 5*, p. 3; Summit Resources Ltd, *Submission no. 15*, p. 25; Deep Yellow Ltd, *Submission no. 16*, p. 2; Australian Nuclear Association, *Submission no. 19*, p. 3; Submarine Institute of Australia, *Submission no. 21*, p. 7; Mr Robert Parsons, *Submission no. 24*, p. 2; Anonymous, *Submission no. 25*, p. 1; Mr Alan Parker, *Submission no. 35*, p. 12; CSIRO, *Submission no. 37*, p. 10; Heathgate Resources Pty Ltd, *Submission no. 49*, p. 1; Southern Gold Ltd, *Submission no. 54*, p. 4; Energy Resources of Australia Ltd, *Submission no. 46*, p. 4.

36 Cameco Corporation, *op. cit.*, p. 9.

37 Compass Resources NL, *Submission no. 6*, p. 3.

- 'Nuclear power plants are the single most significant means of limiting increased greenhouse gas emissions while enabling access to economic electricity and providing for energy security.'[38]
- 'Nuclear power is mankind's single greatest opportunity to combat the looming environmental threat of global warming.'[39]
- 'Nuclear power is essential to attaining the goal of reducing the emission of greenhouse gas while at the same time maintaining access to electricity.'[40]
- 'Nuclear energy appears to be the only source which can provide safe, reliable and substantial base-load power without producing large quantities of greenhouse gases.'[41]
- 'Nuclear power is the only proven large scale technology for baseload power supply which does not release substantial amounts of carbon dioxide.'[42]

4.33 Nuclear power produces no GHG emissions during electricity generating operations. A nuclear power plant does not emit combustion gases when producing steam and therefore 'a nuclear power plant is a CO_2-free energy source at point of generation.'[43]

4.34 On a fuel basis, coal releases some four tonnes of CO_2 for every tonne of oil equivalent burned, oil releases some 3.2 tonnes of CO_2 for every tonne burned and natural gas releases 2.3 tonnes of CO_2 for every tonne of oil equivalent burned. Nuclear plants emit no CO_2.[44]

4.35 Uranium is also a highly concentrated source of energy when compared to fossil fuels. Uranium contains some 10 000 times more energy per kilogram of fuel than traditional fossil fuel sources. The typical energy output per kilogram of various fuels are listed in table 4.1.

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38 UIC, *Submission no. 12*, p. 14.

39 Arafura Resources NL, *Submission no. 22*, p. 1.

40 Areva, *Submission no. 39*, p. 2.

41 Mr Robert Parsons, *Submission no. 24*, p. 2.

42 AMEC, *loc. cit*.

43 Paladin Resources Ltd, *Submission no.47*, p. 5. See also: Australian Government Department of the Environment and Heritage (DEH), *Submission no. 55*, p. 5; Geoscience Australia (GA), *Submission no. 42*, p. 26.

44 Cameco Corporation, *op. cit*., p. 8.

Table 4.1 Energy output per kilogram of various fuels

Rank	Fuel source	Energy output per kilogram of fuel (megajoules)
1	Uranium	500 000
2	Crude oil	45
3	Natural gas	39*
4	Black coal	30
5	Firewood	16
6	Brown coal	9

Source Arafura Resources NL, *Submission no. 22*, p. 4. * per cubic metre

4.36 Fuel derived from one tonne of natural uranium can produce more than 45 000 megawatt-hours (MWh) of electricity. To produce this amount of electricity from fossil fuels would require burning 20 000 tonnes of black coal, 80 000 barrels of oil or 13 million cubic metres of gas.[45] However, burning one tonne of black coal emits approximately 2.75 tonnes of CO_2. Hence, to generate the same amount of electricity that can be produced with one tonne of uranium, a coal-fired station would emit some 55 000 tonnes of CO_2. To operate a typical coal-fired power plant with 1 000 megawatts electrical (MWe) capacity requires some 3 million tonnes (Mt) of black coal, which emits some 7–8 Mt of CO_2 per year.[46]

4.37 According to the Minerals Council of Australia (MCA) and other submitters, every 22 tonnes of uranium (equivalent to 26 tonnes of uranium oxide—U_3O_8) used in generating electricity saves the emission of one million tonnes of CO_2, relative to using coal with current technologies.[47]

4.38 While precise estimates of the global emissions avoided due to the use of nuclear power vary, submitters generally agreed that nuclear energy avoids more than 600 million tonnes of carbon emissions or some 2.5 billion tonnes of CO_2 per year.[48] That is, nuclear power currently saves about 10 per cent of total CO_2 emissions from world energy use.[49] The

45 See for example: UIC, *Submission no. 12*, pp. 10, 21; Cameco Corporation, *loc. cit.* AMP Capital Investors Sustainable Funds Team provided a similar estimate in *Exhibit no. 65, The Nuclear Fuel Cycle Position Paper*, p. 13. The amount of energy produced depends on the type of reactor and the enrichment level of the fuel.

46 AMEC, *op. cit.*, p. 7.

47 Mr Mitch Hooke (MCA), *Transcript of Evidence*, 5 September 2005, p. 20. See also: Southern Gold, *Submission no. 54*, p. 9; AMEC, *op. cit.*, p. 8.

48 UIC, *op. cit.*, p. 14. See also: Compass Resources NL, *Submission no. 6*, p. 3; Nova Energy Ltd, *op. cit.*, p. 19; Professor Leslie Kemeny, *Exhibit no. 7, Nuclear Energy and the Greenhouse Problem*, p. 1; AMEC, *loc. cit*; Cameco Corporation, *op. cit.*, p. 9. Cameco estimates savings of 2.2 Gt of CO_2 per year, while AMEC estimates savings of 2.3 Gt.

49 Professor Leslie Kemeny, *ibid*.

World Nuclear Association (WNA) estimates that the emissions avoided are equivalent to approximately one half of the CO_2 emitted by the world's motor vehicles.[50]

4.39 If the electricity currently generated by nuclear power were instead generated by fossil fuels, the increase in global CO_2 emissions would be dramatic. AMP Capital Investors Sustainable Funds Team (AMP CISFT), which is opposed to the use of nuclear power, conceded that:

> If modern fossil fuelled plants produced the electricity that is currently generated by nuclear power plants, then CO_2 emissions would be 8% higher from the energy sector and 17% higher from the electricity generation sector.[51]

4.40 Evidence also revealed that countries with a higher proportional share of nuclear energy in their electricity generation mix are the world's lowest emitters of greenhouse gasses.[52]

4.41 In relation to electricity generation in the US specifically, ANSTO noted that if that country had *not* adopted nuclear power, total emissions of CO_2 would be 29 per cent higher than they currently are. That is, the US nuclear program is saving the equivalent of almost 30 per cent of the country's total emissions.[53]

4.42 ANSTO observed that of the emission-free energy sources in the US; that is, sources that produce little or no CO_2, nuclear produces some 72 percent of the total, hydro about 26 per cent, with small amounts contributed by wind, geothermal and solar. For ANSTO, this means that 'if you take the fossil fuel side out of it then nuclear forms a big part of the ability to have emission-free generation.'[54]

4.43 These conclusions have also been reached in international fora. The International Ministerial Conference, *Nuclear Power for the 21st Century*, held in Paris during March 2005, noted that:

> The health of the planet's environment, including action to reduce air pollution and address the risk of global climate change, is a serious concern that must be regarded as a priority by all Governments.[55]

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50 WNA, *The environment needs nuclear*, viewed 14 May 2006, <http://www.world-nuclear.org/pdf/The_Environment_Needs_Nuclear.pdf>.

51 AMP CISFT, *Exhibit no. 65, The Nuclear Fuel Cycle Position Paper*, p. 13. See also: The Hon Alexander Downer MP, *Submission no. 33*, p. 6.

52 Nova Energy Ltd, *op. cit.*, p. 20.

53 Dr Ron Cameron (ANSTO), *Transcript of Evidence*, 13 October 2005, p. 5. See also: Northern Land Council, *Submission no. 78*, p. 4.

54 Dr Ron Cameron, *op. cit.*, p. 2.

55 Cited in the Hon Alexander Downer MP, *loc. cit.*

The Conference affirmed that nuclear power could make a contribution to meeting energy needs and sustaining the world's development in the 21st Century because nuclear 'does not generate air pollution or greenhouse gas emissions'.[56]

Australia's uranium exports displace global emissions

4.44 In terms of the emission savings attributable to Australia's uranium exports, the Australian Government Department of the Environment and Heritage (DEH) noted that Australia's uranium exports of 9 593 t U_3O_8 in 2002–03 could have produced some 413 640 gigawatt-hours (GWh) of electricity. If this amount of electricity was produced from black coal generation, more than 395 Mt of CO_2 would be emitted and 'this represents around 70% of Australia's total greenhouse gas emissions for 2003'.[57]

4.45 Assuming that Australia's uranium does not displace uranium sourced from other countries, DEH estimated that:

> Australia's total inferred, low cost, uranium reserves could displace nearly 40,000 Mt CO2e if it replaced black coal electricity generation. This represents almost 5 years of emissions from world public electricity and heat production at 2002 levels …[58]

4.46 To place these GHG displacement estimates in the context of specific uranium mine production, Heathgate Resources (owners of Beverley, Australia's smallest uranium mine) submitted that its annual production generates the same amount of electricity as 16 Mt of coal and thereby avoids 33 Mt of CO_2 that would be emitted by coal-fired plants.[59]

4.47 Paladin Resources argued that Australia's uranium industry complements the coal industry because uranium exports 'neutralise' the carbon content of Australia's thermal coal exports, 'by generating in our customer countries an amount of carbon-free electricity to balance the inevitable carbon emissions of burning the coal equivalent.'[60] Moreover, Paladin Resources suggested that 'a good argument can be made that uranium exports should earn credits against CO2 taxes imposed on coal combustion in some jurisdictions.'[61]

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56 *ibid*.

57 DEH, *loc. cit*. See also: Dr Clarence Hardy (ANA), *Transcript of Evidence*, 16 September 2005, p. 53.

58 *ibid*.

59 Heathgate Resources Pty Ltd, *Exhibit no. 57, loc. cit*.

60 Paladin Resources Ltd, *op. cit*., p. 4.

61 *ibid*., p. 5.

4.48 DEH noted however that under current international arrangements, the emissions from producing uranium would be attributed to Australia, but the emissions savings from its consumption in electricity generation would accrue to the country that uses it. Nonetheless, as Nova Energy argued, 'the growth of uranium exports will contribute to global greenhouse gas and CO_2 emissions reductions.'[62]

Future emission savings from use of nuclear power

4.49 To the extent that uranium is used in nuclear power plants which are constructed instead of fossil fuel plants, further export of Australia's uranium will prevent additional emissions of greenhouse gasses.[63]

4.50 As noted above, evidence stated that use of nuclear power avoids the emission of approximately 600 million tonnes of carbon per year (MtC).[64] This estimate is based on the assumption that, in a hypothetical non-nuclear world, all non-nuclear sources would expand their contributions proportionately, with the exception of hydropower which is more constrained than other sources of electricity.[65]

4.51 The IAEA stated in its 2003 study, *Nuclear Power and Climate Change*, that compared with the carbon avoidance promised by the Kyoto Protocol, which will reduce annual carbon emissions in 2010 by less than 350 MtC:

> … nuclear power *already* contributes reductions more than twice the likely reductions from the Kyoto Protocol seven years down the road.[66]

4.52 In terms of the quantity of carbon that will be avoided by use of nuclear power in the future, estimates vary depending on forecasts for the future evolution of the electricity generating mix and the likely reductions in the carbon intensity of different generation options. For its projections, the IAEA adopted the conservative assumptions of the IEA in its *World Energy Outlook 2002* report; that no new nuclear plants will be constructed beyond those currently being built or seriously planned, and that reactors will be retired as previously scheduled. If the world develops along this path, by 2030 cumulative carbon emissions avoided that are attributable to nuclear power could be some 17 billion tonnes (GtC).[67]

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62 Nova Energy Ltd, *loc. cit*.

63 ANSTO, *Submission no. 29*, p. 8.

64 The Hon Alexander Downer MP, *loc. cit*. This is the elemental carbon component of carbon dioxide.

65 H Rogner, *Nuclear Power and Climate Change*, IAEA, Paris, 2003, p. 4.

66 *ibid*., p. 8. Emphasis in original. Cameco Corporation, *loc. cit*.

67 *ibid*., p. 6.

4.53 If nuclear power expands its contribution to world energy supplies in the future, rather than contracts as in the IEA scenario presented above, then emissions avoided that are attributable to nuclear power could be far greater. Adopting the emissions scenarios developed by the IPCC, the IAEA has estimated that cumulative carbon emissions avoided by nuclear power will exceed 20 GtC by 2030 under all scenarios.[68] This amounts to some 74 Gt of CO_2 avoided due to use of nuclear power.

4.54 Cameco observed that in some emissions scenarios, the cumulative carbon savings from nuclear over the three decades to 2030 will actually exceed 25 GtC.[69]

Nuclear power's other environmental benefits

4.55 In addition to displacing emissions of CO_2, it was argued that nuclear power relieves general air and surface pollution. Several submitters emphasised that the environmental impacts of coal and gas-fired power stations are significantly greater than those of nuclear power plants.[70] A comparison between coal, gas and nuclear plants of equal capacity follows.

4.56 A coal-fired power station with a capacity of 1 300 MWe will consume approximately 3.3 Mt of black coal per year and require a transport component of 82 500 rail cars each of 40 tonnes capacity. The land use requirement for a plant of this size, including fuel storage and waste disposal, will be around 415 hectares. Depending on the quality of the coal and other factors, the emissions will be in the order of 10 Mt of CO_2, 2 300 tonnes of particulates, 200 000 tonnes of sulphur dioxide and 7 000 tonnes of nitrous oxide. The plant would also produce some 250 000 tonnes of fly ash containing toxic metals including arsenic, cadmium, mercury, organic carcinogens and mutagens and naturally-occurring radioactive substances.[71]

4.57 A gas combined cycle plant of the same capacity will consume 1.9 billion cubic metres of gas per year and emit 5 Mt of CO_2, 30 tonnes of sulphur dioxide, 12 700 tonnes of nitrous oxide and 410 tonnes of methane.[72]

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68 *ibid*., p. 8.

69 Cameco Corporation, *loc. cit*.

70 Mr John Reynolds, *Submission no. 5*, p. 5; Energy Resources of Australia Ltd, *Exhibit no. 82, Ranger overview presentation*, p. 16; Southern Gold Ltd, Submission no. 54, pp. 9–10.

71 Professor Leslie Kemeny, *op. cit*., p. 3. See also: Professor Leslie Kemeny, *Exhibit no. 28, Renewable energy debate makes little sense*; Energy Resources of Australia Ltd, *loc. cit*. Precise quantities of emissions would depend on the coal quality, power plant design, thermal efficiency, effectiveness of the abatement system and the operational performance of the plant.

72 Professor Leslie Kemeny, *Exhibit no. 7*, *op. cit*., p. 4.

4.58 In contrast, a 1 300 MWe nuclear power plant, which requires a land area of some 60 hectares, will consume some 32 tonnes of enriched uranium per year, produced from around 170 tonnes of natural uranium in the form of uranium oxide concentrate. The plant would produce some 4.8 cubic metres of used fuel per year.[73] The wastes produced in the operation of nuclear power plants and in the various stages of the fuel cycle are further described in chapter five.

4.59 In comparing the environmental consequences of using fossil fuels with nuclear power, Cameco restated British environmentalist Sir James Lovelock's suggestion that people try to imagine they are a government minister required to decide what fuel to use for a new power station being built to supply half a large city:

> Every year, there are the following environmental consequences: using coal requires a 1,000 kilometre line of railway cars filled with coal which will emit billions of cubic feet of greenhouse gases, creates dust and more than 500,000 tonnes of toxic ash; using oil needs four or five-super tanker loads of heavy oil imported from unstable parts of the world, emits nearly as much greenhouse gases as coal plus huge volumes of sulphur and other deadly compounds that turn into acid rain; importing natural gas over long distances by ships and pipelines prone to accidents and leaks, emissions are highly polluting and the gas supply is vulnerable; or about two truckloads of cheap and plentiful uranium with essentially no emissions.[74]

4.60 While natural gas emits less CO_2 than coal, several submitters expressed reservations about its expanded use for baseload power generation on the grounds that there are relatively small global resources and these are said to be poorly located relative to centres of high potential economic growth. AMEC also raised concerns about the opportunity cost in using gas for large-scale electricity generation and inter-generational equity.[75]

4.61 The Committee also received evidence suggesting that nuclear power causes virtually the least environmental damage of all major energy technologies. Based on estimates of the unit cost of various pollutants (carbon dioxide, lead, nitrous oxide, particulates, sulphur dioxide and so on) in US dollars per tonne, Lucent Technologies have determined the damage to the environment per kilowatt-hour in dollar terms for a range

73 *ibid*., p. 3. Maintenance of a nuclear reactor of this size would also produces some 531 cubic metres of low level waste and 47 cubic metres of intermediate level waste per year.

74 Cameco Corporation, *loc. cit*.

75 Arafura Resources NL, *op. cit*., p. 5; AMEC, *op. cit*., p. 6; Mr Keith Alder, *Transcript of Evidence*, 16 September 2005, p. 80.

of energy technologies. These environmental damage costs are listed in table 4.2. According to this estimate, wind power causes the least environmental damage, followed by nuclear power. Fossil fuel energy sources cause by far the most environmental damage in dollar terms.[76]

Table 4.2 Life cycle damage cost from major energy technologies (1999)

Technology	Damage cost (USc/kWh)
Wind	0.005 – 0.008
Nuclear	0.04
Hydro	0.073
Solar PV	0.231 – 0.376
Natural gas	1.04
Coal	1.59 – 6.02

Source ANSTO, *Exhibit no. 74, Presentation by Dr Ron Cameron and Dr Ian Smith*, p. 34.

A moral responsibility to export uranium?

4.62 As noted in the discussion of energy demand above, forecast levels for energy use would trigger a significant increase in CO_2 emissions, with the IEA predicting that energy-related CO_2 emissions will reach 37 Gt annually by 2030—an increase of 52 per cent over the 2003 level.

4.63 Arafura Resources explained that while world economic growth to 2010 is forecast to average 3.5 per cent, India and China are forecast to grow at 6 per cent and 9.5 per cent respectively. Combined, these countries currently have some 37.5 per cent of the world's population. However, Arafura argued that India and China:

> … already have environmental conditions that are approaching crisis point. China has 9 out of the 10 most polluted cities in the world. Approximately 70% of China's energy needs come from brown coal, the least efficient and dirtiest fossil fuel for energy generation.[77]

4.64 Summit Resources also spoke of the imperative for countries like China to have their energy requirements supplied by non fossil fuel sources:

> … what we have to face is that China's economy is growing and they want to improve their standard of living. The biggest thing that the Chinese are going to consume is not KFC and not Coca-Cola but energy. If we sit here and just keep letting them build more coal-fired power stations, we are all going to suffer.[78]

76 Dr Ian Smith, *op. cit.*, p. 14.

77 Arafura Resources NL, *Submission no. 22*, p. 2.

78 Mr Alan Eggers (Summit Resources Ltd), *Transcript of Evidence*, 3 November 2005, p. 14.

4.65 For Nova Energy, nuclear power is a means for these and other developing nations not bound by the Kyoto Protocol, to meet their energy demands in a way which reduces their reliance on fossil fuels:

> Australia's uranium is, potentially, a way to meet the energy demands of these developing countries that obviates their need to depend on fossil fuels and delivers a positive global outcome—more energy for less carbon.[79]

4.66 Similarly, Compass Resources argued that:

> … the only realistic alternative available to meet the increased energy demand is coal or nuclear. Despite likely improvements to coal power plant emissions through geosequestration, use of coal will increase greenhouse gas emissions as the industry is asked to fill the world's energy needs.[80]

4.67 Noting that nuclear electricity has the lowest CO_2 emissions per kilowatt hour of the alternatives for baseload power generation, the Australian Nuclear Forum (ANF) argued that:

> In those countries that are serious about global warming, nuclear will expand and will need fuel. We think that the greatest contribution Australia can make to the global reduction of CO_2 is to maximise the export of uranium to responsible countries.[81]

4.68 AMEC submitted that the Federal 'government now has a moral responsibility to contribute to reducing global greenhouse emissions' and that 'Australia is well placed to make a significant contribution to greenhouse gas emission reduction targets through increased production and supply of uranium.'[82]

4.69 Cameco was also emphatic that given nuclear power's value as a carbon-free electricity supply technology, the further exploration and development of Australia's uranium resources should be supported and 'Australia should throw the world a climate lifeline.'[83]

4.70 In view of the potential greenhouse benefits, Professor Ralph Parsons argued that 'Australia should encourage those of our major trading

79 Nova Energy Ltd, *op. cit.*, p. 19.

80 Compass Resources, *op. cit.*, p. 3.

81 Mr James Brough (ANF), *Transcript of Evidence*, 16 September 2005, p. 42. Baseload power generation is defined as that part of electricity demand that is continuous and requires reliability.

82 AMEC, *op. cit.*, p. 7.

83 Cameco Corporation, *loc. cit.*

partners which currently produce large quantities of greenhouse gases to use uranium rather than carbon based fuels wherever possible.'[84]

Prominent environmentalists support nuclear power

4.71 The Committee was also informed that a number of prominent environmentalists, who were foundational figures in the environment movement and previously adamantly opposed to nuclear, now support use of nuclear power to avert global environmental calamity. These individuals include Dr Patrick Moore, Bishop Hugh Montefiore and Sir James Lovelock. Excerpts from their writings cited in evidence follow:

- Dr Patrick Moore, one of the co-founders of Greenpeace in 1971 and subsequently its president, has argued that 'nuclear energy is the only non greenhouse gas-emitting power source that can effectively replace fossil fuels and satisfy global [energy] demand.'[85] Dr Moore has also argued that environmental activists who oppose nuclear power have 'abandoned science in favour of sensationalism'.[86]
- Sir James Lovelock, an independent scientist and author of the Gaia hypothesis, has argued that:

  > … by all means, let us use the small input from renewables sensibly, but only one immediately available source does not cause global warming and that is nuclear energy. Opposition to nuclear energy is based on irrational fear fed by Hollywood-style fiction, the Green lobbies and the media. These fears are unjustified, and nuclear energy from its start in 1952 has proved to be the safest of all energy sources. We have no time to experiment with visionary energy sources; civilisation is in imminent danger and has to use nuclear — the one safe, available, energy source — now or suffer the pain soon to be inflicted by our outraged planet.[87]

- Bishop Hugh Montefiore, a trustee of Friends of the Earth (FOE) for two decades and chairman of the organisation between 1992 and 1998, argued that:

  > The dangers of global warming are greater than any others facing the planet. In the light of this I have come to the conclusion that the solution is to make more use of nuclear energy … Nuclear energy provides a reliable, safe, cheap, almost limitless form of pollution free energy. The real reason why the government has not

84 Professor Ralph Parsons, *Submission no. 24*, p. 2.

85 Cited in Professor Leslie Kemeny, *Exhibit no. 8, A power too good to refuse.*

86 *ibid*.

87 Cited in UIC, *op. cit.*, p. 14.

> taken up the nuclear option is because it lacks public acceptance, due to scare stories in the media and the stonewalling opposition of powerful environmental organisations. Most, if not all, of the objections do not stand up to objective assessment.[88]

4.72 For Cameco, the reason these environmentalists have taken this stance is that they rightly recognise that the enhanced greenhouse effect poses a far more serious threat to humankind than the risks associated with use of nuclear energy, notably its relatively small quantities of waste.[89] Indeed, Sir James Lovelock has argued that:

> … I am a Green and I entreat my friends in the movement to drop their wrongheaded objection to nuclear energy.
>
> Even if they were right about its dangers, and they are not, its worldwide use as our main source of energy would pose an insignificant threat compared with the dangers of intolerable and lethal heat waves and sea levels rising to drown every costal city in the world.[90]

4.73 Similarly, the Australian Nuclear Association (ANA) argued that while the perception of risks may vary, 'the cost is that the greenhouse gas problem could be more dangerous in the future … than the risks of radioactive waste if we use nuclear power.'[91]

4.74 The significance of prominent environmentalists taking pro-nuclear positions was disputed by FOE, who argued that most environmentalists remain opposed to use of nuclear power.[92] Similarly, the Environment Centre of the Northern Territory (ECNT) argued that:

> They are still only a tiny, tiny proportion of the people who have ever considered themselves to be, or have been called, environmentalists. The environment groups around the world are extremely solid in saying that we should not be wasting our time going back to nuclear; we should be going forward to renewable energy and energy efficiency.[93]

4.75 In response to the environment movement's continued opposition to nuclear power, Dr Moore argued before the US Senate Committee on Energy and Natural Resources in April 2005 that:

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88 Cited in Jindalee Resources Ltd, *Submission no. 31*, p. 2. See also: H Montefiore, 'Why the planet needs nuclear energy', *The Tablet*, 23 October 2004, viewed 15 August 2005, <http://www.thetablet.co.uk/cgi-bin/register.cgi/tablet-00946>.

89 Mr Jerry Grandey, Cameco Corporation, *Transcript of Evidence*, 11 August 2005, p. 10.

90 J Lovelock, 'Nuclear Power is the only green solution', *loc. cit.*

91 Dr Clarence hardy (ANA), *Transcript of Evidence*, 16 September 2005, p. 57.

92 Dr Jim Green (FOE), *Transcript of Evidence*, 19 August 2005, p. 60.

93 Mr Peter Robertson (ECNT), *Transcript of Evidence*, 24 October 2005, p. 9.

> I believe the majority of environmental activists, including those at Greenpeace, have now become so blinded by their extremism that they fail to consider the enormous and obvious benefits of harnessing nuclear power to meet and secure America's growing energy needs. These benefits far outweigh the risks. There is now a great deal of scientific data showing nuclear power to be an environmentally sound and safe choice.[94]

4.76 Despite media reports of a shift in perspective by WWF Australia, several environmental groups in Australia that submitted to the Committee's inquiry remain opposed to uranium mining and use of nuclear power.[95] The following section summarises the range of criticisms of nuclear power's contribution to GHG emission mitigation.

Arguments critical of nuclear's contribution to greenhouse gas mitigation

Emissions across the whole nuclear fuel cycle

4.77 While it was widely conceded that nuclear power emits virtually no CO_2 at point of generation, numerous submitters argued that the balance of emissions across the whole nuclear fuel cycle is significant. That is, by adding the emissions produced from all other fuel cycle stages—mining and milling, enrichment, fuel fabrication, transport, plant construction, plant decommissioning and waste disposal—to the electricity generation stage, nuclear power produces a relatively large quantity of GHG emissions.

4.78 Examples of statements by submitters making this argument follow:

- 'Nuclear power also contributes to global carbon dioxide production. Huge quantities of fossil fuel are expended for the "front end" of the nuclear fuel cycle, to construct the massive reactor buildings and cooling towers, and to mine, mill, and enrich the uranium fuel.'[96]
- 'While the production of steam in a nuclear reactor is essentially greenhouse-free, the same is not the case for, the mining, transport and enrichment of the uranium concentrate and the decommissioning of the plant … The amount of fossil fuel required in the mining, enrichment,

94 P Moore, *Nuclear Statement to the United States Senate Committee on Energy and Natural Resources*, 28 April 2005, viewed 11 April 2006, <http://www.greenspirit.com/logbook.cfm?msid=70>.

95 See for example: A Hodge, 'WWF boss to push N-power at meeting', *The Australian*, 9 May 2006, p. 3.

96 Ms Janet Marsh, *Submission no. 2*, p. 2.

construction and decommissioning stages ruins the argument that nuclear power is a valid answer to climate change.'[97]

- 'Nuclear power, despite being depicted as "clean and green" by its advocates, is neither. Throughout the exploration and mining phases, the milling and processing, the transporting of processed ore, the building of reactors, the global movement of spent and treated fuel rods, the passage of radioactive wastes … and the final decommissioning of reactors past their use-by date, fossil fuels are extensively used.'[98]
- 'The case for presenting nuclear power as an alternative source of power generation that is less likely to contribute to global warming is very flawed as it does not take into account the whole nuclear power cycle.'[99]
- 'While nuclear power is "environmentally greener" than any other current energy resource, the infrastructure needed to access and mine the ore plus the construction of reactors and waste disposal sites might result in increased levels of greenhouse gas, cancelling the good effects at the power production level.'[100]

4.79 Life cycle emissions analysis presented in evidence refuted these claims. While estimates of the quantity of emissions released from electricity generation sources across their life cycles vary, it is clear that nuclear power emits orders of magnitude *less* CO_2 than fossil fuels and is equivalent to renewables in most cases:

> Nuclear power creates the lowest amount of CO_2 emissions compared with coal (highest), gas, solar photovoltaic, and in some cases wind. The only rival to nuclear is hydro.[101]

4.80 Several estimates of the emissions from electricity generation chains were submitted in evidence and some of these are listed below. Life cycle emissions are generally quoted in terms of grams of carbon dioxide emitted per kilowatt-hour of electricity produced (gCO_2/kWh). The range of estimates are comparable:

- UIC estimated that nuclear emits some 20 gCO_2/kWh, while black coal emits 950 gCO_2/kWh and gas emits 500 gCO_2/kWh.[102]

97 Wind Prospect Pty Ltd, *Submission no. 4*, p. 3.

98 Medical Association for the Prevention of War—WA Branch, *Submission no. 8*, p. 8.

99 Mr John Schindler, *Submission no. 10*, p. 2.

100 Ms Caroline Pembroke, *Submission no. 81*, p. 2.

101 Paladin Resources Ltd, *op. cit.*, p. 5.

102 UIC, *op. cit.*, p. 14.

- Areva estimated that nuclear emits 12 gCO_2/kWh, while lignite emits 1.1kg of CO_2/kWh, coal emits 932 gCO_2/kWh, oil emits 777 gCO_2/kWh, gas emits 439 gCO_2/kWh, hydro (dam) emits 12.5 gCO_2/kWh, wind emits 9 gCO_2/kWh and hydro (river) emits 5.1 gCO_2/kWh.[103]
- Geoscience Australia (GA) estimated that nuclear emits 5 gCO_2/kWh.[104]
- CSIRO estimated that nuclear emits less than 40 gCO_2/kWh, compared to 760 gCO_2/kWh from a 'state-of-the-art pulverised fuel fired station firing black coal at around 41 per cent overall thermal efficiency.'[105]
- Australian Institute of Nuclear Science and Engineering (AINSE) estimated that nuclear, hydro and wind emit under 10 gCO_2/kWh, while solar emits approximately 100 gCO_2/kWh.[106]

4.81 These various estimates suggest that fossil fuels emit between 18 and 92 times the CO_2 of nuclear power across the full electricity production chains, while nuclear is comparable to—and in some cases less than—renewables.

4.82 Groups critical of nuclear power cited other studies, such as those published by the German Oko Institut, which were said to have found that nuclear emits between 34–60 gCO_2/kWh over its full fuel cycle, while wind emits approximately 20 gCO_2/kWh. Similarly, the Medical Association for the Prevention of War (Victorian Branch) argued that on a full life cycle basis nuclear produces between 1.5 and 3 times as much CO_2 as wind generation.[107]

4.83 The Australian Conservation Foundation (ACF) and Dr Helen Caldicott cited research by Jan Willem Storm van Leeuwen and Philip Smith claiming that nuclear power emits only three times less GHG than modern natural gas power stations.[108]

4.84 Some environmental groups conceded that nuclear power is far less carbon intensive than fossil fuel alternatives. For example, FOE stated that electricity from fossil fuels is far more greenhouse intensive than nuclear.

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103 Areva, *op. cit.*, p. 5. Areva cite estimates published by the World Energy Council in 2004.

104 GA, *Submission no. 42*, p. 26.

105 CSIRO, *op. cit.*, p. 10.

106 AINSE, *Submission no. 77*, p. 3.

107 Medical Association for the Prevention of War—Victorian Branch (MAPW), *Submission no. 30*, p. 10.

108 ACF, *Submission no. 48*, p. 13; Dr Helen Caldicott, *Exhibit no. 73, Nuclear Reactions*, p. 2; Dr Helen Caldicott, *Transcript of Evidence*, 16 September 2005, p. 15. See also: Mr Justin Tutty, *Submission no. 41*, p. 2; Wind Prospect Pty Ltd, *op. cit.*, p. 3. For a critique of the van Leeuwen and Smith study see: UIC, *Energy Analysis of Power Systems*, Nuclear Issues Briefing Paper No. 57, UIC, Melbourne, 2006, viewed 18 May 2006, <http://www.uic.com.au/nip57.htm>.

However, it was argued that nuclear power emits more GHG than most renewables, but again FOE conceded that the difference is small.[109]

4.85 AMP CISFT, which argued that nuclear power is not environmentally sustainable, conceded that nuclear's major benefit is that it 'is one of the least carbon intensive generation technologies.'[110] AMP CISFT estimated that nuclear emits between 9.2–20.9 gCO_2/kWh, compared to 385g–1.3kg CO_2/kWh for fossil fuel chains and 9.2–278.7 gCO_2/kWh for renewables.[111]

4.86 The range of greenhouse gas emissions emitted across electricity production chains for different sources of electricity as determined by the IAEA are depicted in figure 4.2. As with the estimates above, these figures include emissions across the entire nuclear power chain—from mining uranium ore to nuclear waste disposal and reactor construction. Emissions range from 366 grams of carbon equivalent per kilowatt-hour (gC_{eq}/kWh) for lignite, to between 2.5 and 5.7 gC_{eq}/kWh for nuclear power. Wind ranges between 2.5 and 13.1 gC_{eq}/kWh, and solar photovoltaics between 8.2 and 76.4 gC_{eq}/kWh. The IAEA has concluded that:

> The complete nuclear power chain, from resource extraction to waste disposal including reactor and facility construction, emits only 2-6 grams of carbon equivalent per kilowatt-hour. This is about the same as wind and solar power including construction and component manufacture. All three are two orders of magnitude below coal, oil and natural gas.[112]

4.87 Studies have also been made of the carbon emissions by fuel source for specific countries. Table 4.3 lists the life cycle emissions for various sources of electricity generation and fuel types in Japan, Sweden and Finland—countries which have produced authoritative figures. The variation in emission levels for nuclear across the three countries reflects the method of uranium enrichment used (gaseous diffusion or gas centrifuge) and whether the power for enrichment comes from nuclear sources or from fossil sources.

4.88 The data reveals that, other than hydro, nuclear power emits the least CO_2 of all generation methods in each of the countries. Nuclear emits less than one-hundredth of the CO_2 of fossil fuel based generation in Sweden.

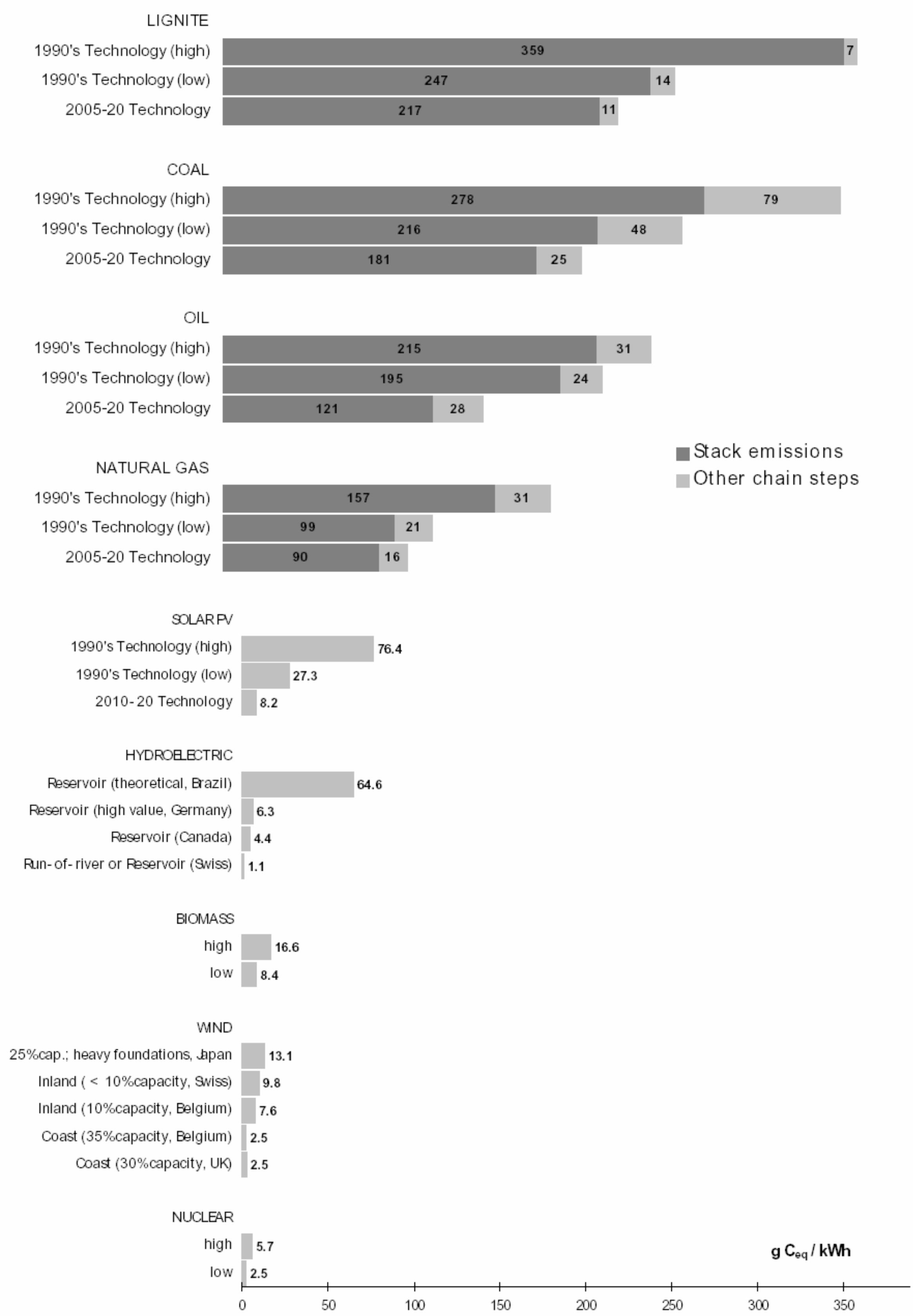
109 FOE, *Submission no. 52*, p. 5.

110 AMP CISFT, *op. cit.*, p. 13.

111 *ibid.*

112 Cited in the Hon Alexander Downer MP, *op. cit.*, p. 2.

Figure 4.2 The range of total greenhouse gas emissions from electricity production chains (measured in grams of carbon equivalent per kilowatt-hour of electricity generated)



Source Hans-Holger Rogner, et. al., *Nuclear Power: Status and Outlook*, IAEA, Vienna, 2002, p. 5.

4.89 The ANA argued that emissions from nuclear are below wind in Japan and marginally above wind in Sweden and Finland. The reasons for this are that wind and solar are diffuse sources of energy and they have a low capacity factor. In addition, solar and wind both produce CO_2 during the construction process for the towers, turbines and generators.[113]

Table 4.3 Grams of carbon dioxide emitted per kilowatt-hour of electricity produced by different generation methods in Japan, Sweden and Finland

Generation method	Japan	Sweden	Finland
Coal	975	980	894
Gas $_{\text{Thermal}}$	608	1170	—
Gas $_{\text{Combined Cycle}}$	519	450	472
Solar photovoltaic	53	50	95
Wind	29	5.5	14
Nuclear	22	6	10 – 26
Hydro	11	3	—

Source ANSTO, *Exhibit no. 74, Presentation by Dr Ron Cameron and Dr Ian Smith,* p. 32. UIC, *Submission no. 12*, p. 15.

4.90 GA submitted the life cycle emissions data contained in table 4.4, which lists the GHG emissions for different sources of electricity generation and fuel types for France and other European countries. The table lists the emissions released at the point of generation or operation, emissions across the remainder of the electricity production chains and the total for each source of electricity.

4.91 In this data, natural gas releases 182 times more CO_2 over its full electricity production chain than nuclear, and coal releases over 200 times more CO_2 than nuclear. Nuclear and hydro have the same life cycle emissions per unit of electricity produced and wind is marginally lower.

113 Dr Clarence Hardy, *op. cit.*, p. 54.

Table 4.4 Greenhouse gas emissions for different sources of electricity generation and fuel types, typical for France and other European countries (2004)

Energy source	Operation grams of CO_2 equivalent per kW hour	Remainder of cycle grams of CO_2 equivalent per kW hour	Total grams of CO_2 equivalent per kW hour
Coal 600 MWe	892	111	1 003
Fuel oil	839	149	988
Gas turbine	844	68	912
Diesel	726	159	895
Hydro-pumped storage	127	5	132
Photovoltaic	0	97	97
Hydroelectric	0	5	5
Nuclear energy	0	5	5
Wind generation	0	3	3

Source Geoscience Australia, *Submission no. 42*, p. 26.

Enrichment and declining uranium ore grades

4.92 Critics of nuclear power's GHG mitigation potential raised the issues of the energy required to power uranium enrichment plants and the additional energy that may be required to mine and mill uranium as ore grades decline. That is, as higher grade ores are exhausted, a greater amount of energy may need to be expended for extraction and processing, and hence overall CO_2 emissions may increase.

4.93 In relation to uranium enrichment, which is discussed further in chapters seven and twelve, there are currently two enrichment technologies in large scale commercial use: gaseous diffusion and newer gas centrifuge enrichment plants. There are currently two of the older gaseous diffusion plants remaining in operation—one in France (operated by Areva) and another in the US (operated by the US Enrichment Corporation, USEC). These plants account for approximately 40 per cent of world enrichment capacity.[114]

4.94 It was argued that enrichment plants consume enormous quantities of electricity and emit large quantities of chlorofluorocarbons (CFCs), which are ozone depleting as well as being significant greenhouse gases.[115]

4.95 Silex confirmed that the first generation gaseous diffusion enrichment technology consumes large amounts of electricity. The gaseous diffusion plant in Paducah, Kentucky, consumes one-half of one per cent of all

114 UIC, *Uranium Enrichment*, Nuclear Issues Briefing Paper No. 33, UIC, Melbourne, 2006, viewed 19 May 2006, <http://www.uic.com.au/nip33.htm>.

115 Dr Helen Caldicott, *Exhibit no. 24, Nuclear power is the problem, not a solution*, pp. 1–2; People for Nuclear Disarmament NSW Inc, *Submission no. 45*, p. 6; Ms Janet Marsh, *loc. cit.*

electricity generated in the US. The Paducah plant also operates with CFCs and has a dispensatory license allowing it to do so. Areva and USEC have indicated their intention to phase out these plants.[116]

4.96 ANA stated that while gaseous diffusion plants consume a large amount of electricity, these are being replaced by centrifuge enrichment plants which use less than one-tenth of the electricity previously required.[117] Whereas a gaseous diffusion plant would use 2 500 kWh per unit of production (a separative work unit, SWU), a centrifuge plant would only require between 50 and 100 kWh per SWU.[118]

4.97 Mr Keith Alder, formerly the General Manager and then a Commissioner of the Australian Atomic Energy Commission, also dismissed arguments critical of the energy balance in relation to enrichment plants, arguing that centrifuge technology has dramatically reduced the amount of energy required, down by a factor of 20 compared to gaseous diffusion plants.[119]

4.98 GA observed that the whole of life cycle emission rate for nuclear power in France listed in table 4.4 (5 gCO_2/kWh) is lower than the industry average cited by the UIC (20 gCO_2/kWh) because nuclear reactors are used to power the enrichment plants in France, whereas in other countries the electricity for enrichment is supplied by coal-fired power stations.[120]

4.99 The ANA agreed, noting that the gaseous diffusion plant in France, which is to be replaced by centrifuge technology, is powered by four dedicated nuclear power plants and so the enrichment process in that country emits no CO_2.[121] The gaseous diffusion plant operating in the US is powered by coal. However, the ANA and Silex estimated that within ten years all existing gaseous diffusion plants will be replaced by centrifuge enrichment plants. There are now four of the newer plants worldwide, with two currently in operation, and there are plans to build more.

4.100 The UIC observed that while enrichment can be greenhouse intensive, it still accounts for a small share of carbon emissions:

> [Enrichment] can also account for the main greenhouse gas impact from the nuclear fuel cycle if the electricity used for enrichment is generated from coal. However, it still only amounts to 0.1% of the carbon dioxide from equivalent coal-fired electricity generation if

116 Dr Michael Goldsworthy (Silex Systems Ltd), *Transcript of Evidence*, 9 February 2006, p. 8.

117 Dr Clarence Hardy, *op. cit.*, p. 53.

118 UIC, *Uranium Enrichment*, *loc. cit.*

119 Mr Keith Alder, *Transcript of Evidence*, 16 September 2005, p. 87.

120 GA, *op. cit.*, p. 26.

121 Dr Clarence Hardy, *op. cit.*, p. 58.

modern gas centrifuge plants are used, or up to 3% in a worst case situation.[122]

4.101 It was also argued that over coming decades increased energy inputs will be required to extract and process lower grade uranium ores, and that the energy required to extract uranium will rise to the extent of making the net energy yield from nuclear power very small. It was argued that as energy inputs increase, CO_2 emissions will rise to near fossil fuel levels.

4.102 A number of submitters advanced this argument. For example, DEH argued that the GHG emission benefit of nuclear power may indeed diminish as the quality of uranium ores decline: 'The lower the quality of the ore, the more greenhouse gas intensity increases.'[123] Similarly, Dr Gavin Mudd claimed that:

> If you look at Olympic Dam, both its current operations and its future operations, and Ranger et cetera, there will be at least one millions tonnes of CO_2 released a year. If those operations expand, that figure will obviously increase. One of the issues is that to get the uranium out in the future is going to require more energy, so there will be more relative CO_2 emissions.[124]

4.103 The argument was also made by other witnesses, including FOE, ACF, the Public Health Association (PHA), MAPW and Greenpeace who issued a joint statement, *Nuclear Power: No Solution to Climate Change*. This statement claimed that:

> … the mining of lower grade ores is likely to have significant implications in relation to energy usage and greenhouse gas emissions. The energy required to extract uranium from low grade ores may approach the energy gained from the uranium's use in power reactors. Likewise, the increased greenhouse gas emissions from mining and milling low grade ores will narrow nuclear's greenhouse advantage in relation to fossil fuels, and widen nuclear power's deficit in comparison to most renewables energy sources.[125]

4.104 The argument draws again on a study by Storm van Leeuwen and Smith (SLS), now comprehensively critiqued, which purports to compare the energy inputs and outputs for nuclear power, and asserts that mining and

122 UIC, *Uranium Enrichment, loc. cit.*

123 Mr Barry Sterland (DEH), *Transcript of Evidence*, 10 October 2005, p. 14.

124 Dr Gavin Mudd, *Transcript of Evidence*, 19 August 2005, p. 42.

125 FOE et. al., *Exhibit No. 71, Nuclear Power: No Solution to Climate Change*, section 2.2. The argument was also made by: Wind Prospect Pty Ltd, *op. cit.*, p. 3; Mr Alan Parker, *Submission no. 35*, p. 11; Mr Justin Tutty, *Submission no. 41*, p. 3; Dr Helen Caldicott, *Transcript of Evidence, loc. cit.*

milling uranium are major energy costs. SLS argue that although the production of electricity leads to 'considerably less' CO_2 emissions than fossil fuels:

> In the course of time, as the rich ores become exhausted and poorer and poorer ores are perforce used, continuing use of nuclear reactors for electricity generation will finally result in the production of more CO_2 than if fossil fuels were to be burned directly.[126]

4.105 The UIC, WNA and academics from the School of Physics at the University of Melbourne, among others, have published detailed responses to the SLS study and emphatically rebutted the claims made.[127] In brief, the UIC argued that the SLS 'assertions ignore hard data and misunderstand the concept of mineral resources.'[128]

4.106 It was argued that a typical life cycle analysis of nuclear energy shows that total energy inputs are only about two per cent of outputs (which is comparable to wind generation), or less.[129] An audited life cycle analysis of the Forsmark nuclear power plant in Sweden showed that energy inputs are in fact 1.35 per cent of output. It was argued that if uranium with much lower ore grades is used, the total energy inputs rise to only about 2.5 per cent of outputs.

4.107 Similarly, the Melbourne University physicists group have argued that the SLS paper 'grossly over estimates the energy cost of mining low-grade ores'.[130] Employing the SLS calculations, the group predicted that the energy cost of extracting Olympic Dam's annual uranium production would require the energy equivalent to almost two one-gigawatt power plants running for a full year (two gigawatt-years). In fact, this is larger than the entire electricity production of South Australia and an order of magnitude more than the measured energy inputs for the mine.[131]

4.108 The UIC argued that the energy costs of uranium mining and milling are well known and published. The energy cost are said to form a small part

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126 The Storm van Leeuwen and Smith paper, *Nuclear Power: the Energy Balance*, is available online, viewed 19 May 2006, <http://www.stormsmith.nl/>.

127 For detailed critiques of the Storm van Leeuwen and Smith studies see: UIC, *Energy Analysis of Power Systems*, Nuclear Issues Briefing Paper No. 57, UIC, Melbourne, 2006, viewed 18 May 2006, <http://www.uic.com.au/nip57.htm>; and by physicists at Melbourne University available online at 'nuclearinfo.net', viewed 18 May 2006, <http://www.nuclearinfo.net/Nuclearpower/TheBenefitsOfNuclearPower>.

128 UIC, *Submission no. 12.1*, p. 1.

129 Compare UIC, *Submission no. 12.1*, p. 1, with Wind Prospect Pty Ltd, *loc. cit*.

130 See: Nuclearinfo.net, *loc. cit*.

131 *ibid*.

of the overall total and 'even if they were ten times higher they would still be insignificant overall.'[132]

4.109 The UIC also argued that by suggesting the need to mine low grade ores is imminent, SLS misunderstand the nature of mineral resources:

> We can be confident that known economic resources of uranium (as of other metal minerals) will increase in line with exploration effort. While ore grades may well decline to some extent, the energy required to utilise them will not become excessive.[133]

Nuclear power 'too limited, slow and impractical to solve climate change'

4.110 Environment groups argued that nuclear power cannot solve climate change because it is too limited, slow and impractical. Nuclear was said to be a limited response to climate change because nuclear power is used almost exclusively for power generation, which is claimed to be 'responsible for less than a third of global greenhouse gas emissions.'[134] As noted above, other anthropogenic sources of GHG emissions include transport and agriculture, and thus:

> Switching the entire world's electricity production to nuclear would still not solve the problem. This is because the production of electricity is only one of many human activities that release greenhouse gases.[135]

4.111 MAPW also argued that the IPCC has concluded that CO_2 emissions must be reduced by at least 70 per cent over the next century to stabilise atmospheric CO_2 concentrations at 450 ppm. It was therefore argued that:

> Reducing CO2 emissions from electricity generation by itself would be insufficient to achieve this target; thus even massive expansion of nuclear power could not by itself be sufficient.[136]

4.112 ACF argued that to reduce emissions by the public energy sector according to the targets of the Kyoto Protocol would require that 72 medium sized nuclear power be built in the EU-15 nations by the end of the first commitment period, 2008–12:

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132 UIC, *Energy Analysis of Power Systems*, *loc. cit.*

133 UIC, *Submission no. 12.1*, *loc cit.*

134 FOE et. al., *Exhibit no. 71*, *op. cit.*, section 2.1. As described in the section in this chapter entitled 'The global energy situation and carbon dioxide emissions' above, the IEA states that the electricity and heat sector contributes 40 per cent of global CO_2 emissions and is the fastest growing sector. FOE argued that electricity is responsible for less than a third of CO_2 emissions, while the ACF stated that electricity accounts for 39 per cent of emissions.

135 ACF, *op. cit.*, p. 13.; PHA, *Submission no. 53*, p. 3.; Ms Jo Vallentine, *Submission no. 73*, p. 2.

136 MAPW (Victorian Branch), *Submission no. 30*, p. 9.

> Leaving aside the huge costs this would involve, it is unlikely that it is technically feasible to build so many new plants in such a short time, given that only 15 new reactors have been built in the last 20 years.[137]

4.113 FOE also argued that a 'nuclear solution to climate change' was impractical because for nuclear to account for 70 per cent of electricity by 2100 would allegedly require 115 reactors to be built each year. In any case, it was claimed that this would 'result in emission reductions relative to fossil fuels of just 16 per cent.'[138]

4.114 FOE and People for Nuclear Disarmament NSW asserted that a doubling of nuclear power output by 2050 would reduce global greenhouse emissions by about 5 per cent, allegedly 'less than one tenth of the reductions required to stabilise atmospheric concentrations of greenhouse gases.'[139]

4.115 Research provided by Dr Helen Caldicott argued that, in addition to being a limited response to climate change, nuclear power is also 'about the slowest option to deploy (in capacity or annual output added)'.[140] It was argued that efficiency gains combined with decentralised sources of energy 'now add at least ten times as much capacity per year as nuclear power.'[141]

4.116 Professor Richard Broinowski expressed scepticism that nuclear power could even be part of the solution to the greenhouse emissions problem:

> The most compelling reasons are that: firstly, electricity generation accounts for only approximately one-third of greenhouse gas emissions; secondly, at least 1,000 nuclear reactors of at least 1,000 megawatts each would have to be constructed, beginning immediately, to make any dent on the contribution power generation makes to global warming; and, thirdly, these would in turn generate enormous quantities of hydrocarbon emissions in the mining and enrichment of the additional uranium, rapidly exhaust economically significant deposits of uranium and significantly increase the problems of disposal of spent nuclear fuel.[142]

4.117 In terms of emissions currently avoided, FOE argued that nuclear avoids some 312 Mt CO_2 per year in the EU countries, relative to use of fossil

137 ACF, *loc. cit*.
138 Dr Jim Green, *op. cit.*, p. 60.
139 FOE, *Submission no. 52*, p. 5; People for Nuclear Disarmament NSW Inc, *op. cit.*, p. 5.
140 Dr Helen Caldicott, *Exhibit no. 68, Nuclear power: economics and climate-protection potential*, p. i.
141 *ibid*.
142 Professor Richard Broinowski, *Transcript of Evidence*, 16 September 2005, p. 17.

fuels. However, FOE argued that the savings drop to half if the comparison is with natural gas cogeneration and zero if compared with hydroelectricity. There are allegedly net costs if nuclear is compared with investment in energy efficiency measures and renewables such as wind generation.[143]

4.118 ACF argued that nuclear is not an answer to the climate change problem because of the 'very long lead time and the high capital investment that is required for nuclear options.'[144] ACF also pointed to the significant opportunity cost involved for countries that choose to build or expand nuclear power. Because resources are finite, countries would necessarily have to forgo other options should it choose to adopt nuclear power. ACF also stressed that the economic competitiveness of renewables would improve over the next 10 to 15 years.

4.119 Similarly, MAPW (WA Branch) pointed to the long-lead times for the construction of nuclear power plants:

> The 10 years needed to plan and build a nuclear power plant, together with the high capital cost, makes the nuclear response to accelerating global warming particularly inappropriate. In fact, I think it would be a recipe for disaster because of the greenhouse gases produced in building those power stations.[145]

4.120 Critics of nuclear power argued that nuclear cannot solve the climate change problem. For example, FOE argued that 'nuclear power is being promoted as *the* solution to climate change, but it is no such thing.'[146] However, no witness or submitter—particularly those from industry—presented evidence to the Committee alleging that nuclear power *alone* could 'solve' climate change, or that nuclear power *alone* could reduce emissions sufficient to prevent further global warming.

4.121 Industry presented a consistently measured response in relation to nuclear power's potential to assist in reducing GHG emissions. For example, the ANA argued that:

> … if you are operating 400 or so nuclear power stations around the world, you are producing less CO_2 per unit of electricity than if you were operating coal or gas stations. Nuclear power, in that sense, can contribute to reducing the greenhouse effect but … nuclear power is not the solution to the greenhouse problem because it can only contribute a small amount as one of several

143 FOE, *op. cit.*, p. 6.

144 Mr David Noonan (ACF), *Transcript of Evidence*, 19 August 2005, p. 81.

145 Dr Peter Masters (MAPW – WA Branch), *Transcript of Evidence*, 23 September 2005, p. 36.

146 FOE, *op. cit.*, p. 5. Emphasis in original.

> energy resources. In general, we in the world are unfortunately very reliant on fossil fuels. We cannot possibly phase them out over a short period, and possibly not even over 20 to 50 years. We will be dependent on them, but we can do everything possible to conserve electricity and use more efficient end-use applications. We can conserve it in that sense and we can supplement it with new baseload and distributed generation from nuclear and renewables which have much lower contributions. That is the point.[147]

4.122 Areva also argued that:

> No-one will ever suggest, and we certainly would not, that nuclear should be the only fuel source, but there is no doubt that it is the most efficient and one of the cleanest sources of energy …
>
> Nuclear power is just one of the many aspects. In a relative sense it is a clean fuel. It does not produce CO_2 which … is creating global warming … Nuclear power will help to reduce that, but there have to be other ways as well. It is not going to stop it, but it will help to reduce it.[148]

4.123 Similarly, BHP Billiton argued that:

> No, [nuclear power] is not the solution, because I do not think there is one solution. I think more efficient carbon capture, better use of fossil fuels, more use of renewables as appropriate and more use of nuclear fuels are all part of the case.[149]

4.124 Heathgate Resources stated that nuclear power is 'one part of the answer' and the ANF argued that nuclear power is 'not going to solve [the climate change] problem by itself', but that 'by having nuclear reactors you certainly could do something to ameliorate it.'[150] Similarly, Nova Energy stated that nuclear 'is only part of that solution.'[151]

4.125 Nonetheless, BHP Billiton noted that while the energy used to mine uranium in Australia is carbon based, a global perspective is needed and use of Australia's uranium makes a significant contribution to GHG mitigation worldwide:

> You have to take a global picture … about 40 per cent of Australia's current greenhouse gas emissions are saved, if you

147 Dr Clarence Hardy, *op. cit.*, p. 54.

148 Mr Stephen Mann (Areva), *Transcript of Evidence*, 23 September 2005, pp. 1, 8.

149 Dr Roger Higgins (BHP Billiton Ltd), *Transcript of Evidence*, 2 November 2005, p. 23.

150 Mr Mark Chalmers (Heathgate Resources Pty Ltd), *Transcript of Evidence*, 19 August 2005, p. 105; Mr James Brough (ANF), *Transcript of Evidence*, 16 September 2005, p. 50.

151 Mr Richard Pearce (Nova Energy Ltd), *Transcript of Evidence*, 23 September 2005, p. 71.

> like—internationally, not in Australia—by virtue of the amount of uranium produced. So it is a major contributor … and a legitimate part of the greenhouse gas debate, but there is no magic solution.[152]

4.126 In terms of the emissions avoided by use of nuclear compared to those saved by renewables, in testimony before the US Senate Committee on Energy and Natural Resources Dr Patrick Moore argued that 'in 2002, carbon emissions avoided by nuclear power were 1.7 times larger than those avoided by renewables.'[153]

4.127 While it was conceded that nuclear power currently avoids emissions in the electricity and heat sector, which contributes 40 per cent of global CO_2 emissions, submitters also argued that nuclear power has the potential to significantly reduce emissions in the transport sector, which is the second largest CO_2 contributor at 24 per cent of the global total.[154]

4.128 Paladin Resources and Cameco, among others, pointed out that nuclear power, particularly reactors currently being developed, could play a significant role in producing hydrogen which may eventually have widespread use in transport and for desalination:

> Looking ahead there is an expectation that hydrogen will play a more important role in energy supply, especially as a transportation fuel to replace greenhouse gas-emitting petrol. Industrial-scale production of hydrogen by electrolysis will require large amounts of electricity, which itself must be generated by a CO2-free source if the total greenhouse loading is to be reduced. Large nuclear power plants obviously have a key role in future hydrogen manufacture. Nuclear power plants are also ideally suited for large scale water desalination plants which may become necessary in some parts of the world as water resources become severely over taxed by social demand.[155]

4.129 CSIRO also observed that:

> … large-scale nuclear energy production allows you an easy route to electrolysis of water to produce oxygen and hydrogen, without

152 Dr Roger Higgins (BHP Billiton Ltd), *loc. cit*.

153 P Moore, *Nuclear Statement to the United States Senate Committee on Energy and Natural Resources*, *loc. cit*.

154 Detailed descriptions of non-electricity uses of nuclear power, including for hydrogen production, are available in the OECD Nuclear Energy Agency publication, *Non-Electricity Products of Nuclear Energy* (2004), viewed 21 May 2006, <http://www.nea.fr/html/ndd/reports/2004/non-electricity-products.pdf>.

155 Paladin Resources Ltd, *op. cit*., p. 6. See also: Mr Jerry Grandey (Cameco Corporation), *Transcript of Evidence*, 11 August 2005, p. 14.

> producing greenhouse gas emissions in any significant way and without the need, as you do in the similar production of hydrogen from coal, to sequester the CO_2.[156]

4.130 The Final Statement from the International Ministerial Conference, *Nuclear Power for the 21st Century*, also observed that nuclear power could make a valuable contribution to sustainable development through the production of hydrogen and potable water (desalination).[157]

4.131 ANSTO informed the Committee that the US Department of Energy (DOE) is moving towards a concept of producing hydrogen by nuclear power through a 'Nuclear Hydrogen Initiative'.[158] The aim of the Initiative is to:

> … demonstrate the economic commercial-scale production of hydrogen using nuclear energy by 2015, and thereby make available a large-scale, emission-free, domestic hydrogen production capability to fuel the approaching hydrogen economy.[159]

Renewables and energy efficiency measures

4.132 Submitters opposed to the use of nuclear power argued that the world's energy needs can be met and major reductions in GHG emissions can be achieved by promoting the use of renewable energy sources, decentralising power generation, adopting energy efficiency measures and significantly reducing energy consumption per capita in industrialised countries.[160] In particular, ACF, FOE, MAPW (WA Branch) and others drew on a study by Keepin and Kats, published in 1988, to argue that:

> … energy efficiency demand management is the most cost effective way of addressing greenhouse gas emissions … for every dollar invested in energy efficiency … realises seven times more

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156 Dr Rod Hill, *op. cit.*, p. 5. See also: Mr John Reynolds, *op. cit.*, p. 7; ANF, *op. cit.*, p. 4.

157 Cited in the Hon Alexander Downer MP, *op. cit.*, p. 7.

158 Dr Ron Cameron, *op. cit.*, p. 10; ANSTO, *Exhibit no. 74, Presentation by Dr Ron Cameron and Dr Ian Smith*, p. 47.

159 US DOE, *Nuclear Hydrogen Initiative*, Office of Nuclear Energy, Science and Technology, viewed 20 April 2006, <http://www.ne.doe.gov/infosheets/hydrogenfactmarch2003.pdf>.

160 See for example: Associate Professor Tilman Ruff (MAPW), *Transcript of Evidence*, 19 August 2005, p. 39; Dr Gavin Mudd, *Transcript of Evidenc*e, 19 August 2005, pp. 42, 43, 55; Dr Jim Green (FOE), *Transcript of Evidence*, 19 August 2005, p. 73; Dr Peter Masters (MAPW – WA Branch), *Transcript of Evidence*, 23 September 205, pp. 36, 38. Mr Justin Tutty, *op. cit.*, p. 7; Uniting Church in Australia (Synod of Victoria and Tasmania), *Submission no. 40*, pp. 14–15; Mr David Addison, *Submission no. 59*, p. 1.

savings in energy and in greenhouse gas emissions than if the same single dollar had been invested in a nuclear proposal.[161]

4.133 Keepin and Kats assert that:

> Opportunities for efficiency gains are so compelling that they suggest that global warming can best be avoided by concentrating on efficiency rather than on a rapid expansion of nuclear power.[162]

4.134 FOE cited a number of alternative studies which assert that energy efficiency and conservation measures, in combination with use of renewables, can deliver reductions in emissions required to stabilise atmospheric concentrations of greenhouse gasses. FOE also argued that reducing growth in energy demand will be essential to reduce emissions, regardless of whether there is a large expansion of nuclear power or renewables. It was argued that the choice of which renewable energy source to deploy (for example, solar or wind) would vary depending on the circumstances of the particular country.[163]

4.135 In the Australian context, FOE and the ECNT cited two studies which propose methods to achieve 'deep cuts' in Australia's GHG emissions:

- Clean Energy Future Group (2004), which concludes that Australia can meet its energy needs from various commercially proven fuels and technologies while cutting greenhouse emissions by 50 percent by 2040 in the stationary energy sector; and an
- Australia Institute study (2002), which claims to show how Australia can reduce greenhouse emissions by 60 per cent by 2050, through a combination of:

> … a major expansion of wind power, modest growth in hydroelectricity, significant use of biomass, niche applications for solar photovoltaics, and a shift away from large-scale thermal generators isolated from load centres towards distributed cogeneration of electricity and heat.[164]

4.136 The ECNT argued that:

> … there are more immediate, cost-effective and environmentally and socially sustainable options that can be pursued, rather than wasting time, money and resources heading off towards the nuclear dead end.[165]

161 Mr David Noonan, *op. cit.*, p. 82. See also: Dr Gary Scott (ECNT), *Transcript of Evidence*, 24 October 2005, p. 4; MAPW (WA Branch), *op. cit.*, p. 7; Ms Jo Vallentine, *Submission no. 73*, p. 2.

162 Cited in FOE et. al., *op. cit.*, section 6.2.

163 FOE, *op. cit.* pp. 6–7. See also: FOE, *Submission 52.3*, pp. 1–11; FOE et. al., *op. cit.*, appendix 1.

164 FOE, *Submission no 52. loc. cit.*

165 Dr Gary Scott, *loc. cit.*

It was argued that nuclear should be replaced by efficient combined cycle gas as a transition away from fossil fuels to generate baseload power.[166]

4.137 The ECNT also argued that it would:

> … be negligent of the committee to endorse an expansion of uranium exports to, say, China, without conducting a thorough examination of the opportunities for, and benefits of, renewable energy technologies and energy efficiency measures, both in Australia and overseas. Indeed, we would go further and encourage the committee to recommend the redirection of Commonwealth funding currently aimed at facilitating the expansion of the coal and uranium sectors towards the renewable sector as well as into reducing baseload electricity demand.[167]

4.138 The Uniting Church in Australia (Victorian and Tasmanian Synod) also recommended that the Australian Government should assist in transferring renewable technologies to developing countries to assist with their greenhouse gas emission reductions and to significantly increase the provision of subsidies for research, development and implementation of renewables.[168] The ECNT also alleged that Australia was 'getting left behind' by failing to export renewable technologies to China.[169]

4.139 In a project of potential significance in Australia, Geodynamics described the GHG displacement potential of the company's 'hot fractured rock' geothermal resources in the Cooper Basin, which could enable Australia to avoid some 38 Mt of CO_2 per year relative to fossil fuelled plants and generate baseload power (estimated at 3 500 MWe). It was argued that the company's geothermal energy project is unique within the renewable sector 'because it can produce low cost, baseload power on a large scale'.[170]

Nuclear power — an essential component in a low-emission energy mix

4.140 Industry argued that nuclear power can make a significant contribution as part of a low-emission energy mix, which should also include renewables and clean coal technologies:

> Australia's uranium producers do not say that nuclear is the only answer to the world's energy needs but they do say that it needs to

166 *ibid.*, p. 5.

167 *ibid.*, p. 3.

168 Uniting Church in Australia (Synod of Victoria and Tasmania), *op. cit.*, p. 3.

169 Dr Gary Scott, *op. cit.*, p. 4.

170 Geodynamics Ltd, *Exhibit no. 64*, pp. 1, 3.

> be regarded as an important part of the mix, which should also include renewable sources where they are available, economic and efficient. We also support the coal industry's endeavours to dramatically reduce carbon dioxide emission from the use of their product and to achieve this economically.[171]

4.141 Energy Resources of Australia (ERA) emphasised that:

> … nuclear power is an essential component of any mix of low-emission power generation technologies required to reduce greenhouse gas production.[172]

4.142 Paladin Resources stated that:

> Responsible and balanced policy would strive for a mix of low-greenhouse energy sources: CO2-free nuclear for baseload power in countries with high ambient power demand; low-CO2 coal, because coal is abundant; natural gas for peaking loads; hydro, wind, tidal, solar where suitable and appropriate. Achieving better energy efficiency in product design and use and reducing excessive consumption in the developed world through better electricity pricing are also important strategies. There is no single panacea, but no likely remedy should be arbitrarily rejected. Windmills and reactors each have parts to play.[173]

4.143 Likewise, Ms Pepita Maiden, a former employee of British Nuclear Fuels, argued that:

> … nuclear power should not necessarily be embraced as the sole solution to climate change issues, it should be accepted and supported as an important part of the world's energy mix.[174]

4.144 The Committee notes that while the IEA has emphasised the key role of energy efficiency measures in reducing global emissions, the Agency has argued that there is no one technology or policy which can stabilise atmospheric GHG emission concentrations. The IEA has concluded that the global energy mix for a sustainable future will require a 'portfolio approach' to policy, technology development and R&D in which nuclear power plays an important part.[175]

171 Mr Ian Hore-Lacy (UIC), *Transcript of Evidence*, 19 August 2005, p. 89.

172 ERA, *Submission no. 46*, p. 4.

173 Paladin Resources Ltd, *op. cit.*, p. 7.

174 Ms Pepita Maiden, *Submission no. 56*, p. 1.

175 Mr Claude Mandil, Executive Director, IEA, 'The Energy Mix of a Sustainable Future', *Delhi Sustainable Development Summit*, New Delhi, 2–4 February 2006, viewed 22 March 2006, <www.iea.org/textbase/speech/2006/Mandil/DSDS.pdf>.

4.145 In a similar vein, the Final Statement from the International Ministerial Conference, *Nuclear Power for the 21st Century*, noted that:

> A diverse portfolio of energy sources will be needed in the 21st century to allow access to sustainable energy and electricity resources in all regions of the world. Efforts will be needed as well to improve energy efficiency, while limiting air pollution and greenhouse gas emissions.[176]

4.146 Emphasising the importance of a mix of energy sources, the World Energy Council concluded at its World Energy Congress held in Sydney in September 2004 that:

> All energy options must be kept open and no technology should be idolised or demonised. These include the conventional options of coal, oil, gas, nuclear and hydro (whether large or small) and the new renewable energy sources, combined of course with energy efficiency.[177]

4.147 The view that the optimum energy supply mix must include nuclear power was also supported by Wind Prospect, a wind energy developer, constructor and operator, working in Australia, UK, Hong Kong and Ireland, who submitted that:

> It is our belief that the optimum energy supply solution, both for Australia and internationally, involves a mix of many energy sources, and that there exists a place for nuclear energy as a source of baseload electricity.[178]

4.148 The MCA emphasised that nuclear power should not be seen as a substitute for coal, renewables or other energy sources because the rate of growth of energy demand globally requires a contribution from all energy sources and, second, the required reductions in greenhouse emissions will not be achieved by energy efficiency measures alone:

> The rate of growth in demand of energy is increasing and, particularly in the industrialised and urbanising countries of China and India and other parts of Asia, there is going to be demand for all sources of energy. We are not looking at uranium as a substitute for coal or other sorts of energy, we are looking across the board and that includes some of the variable load capacity of renewables and maybe also the baseload of hydro …

176 Cited in the Hon Alexander Downer MP, *op. cit.*, p. 6. See also: International Ministerial Conference, *Nuclear Power for the 21st Century*, Final Statement, Paris, 21–22 March 2005, Viewed 16 May 2006, <http://www-pub.iaea.org/MTCD/Meetings/PDFplus/2004/cn122-final-statement.pdf>.

177 Cited in UIC, *Submission no. 12*, p. 14.

178 Wind Prospect Pty Ltd, *op. cit.*, p. 1.

> because we are not going to get within a bull's roar of what the scientists are telling us we have to do in terms of [greenhouse gas emission] reductions just through energy efficiency …[179]

4.149 However, research cited by Dr Helen Caldicott disputed the argument that a mix of energy options is required or even possible:

> The claim that 'we need all energy options' has no analytic basis and is clearly not true; nor can we afford all options. In practice, keeping nuclear power alive means diverting private and public investment from the cheaper market winners—cogeneration, renewables, and efficiency—to the costlier market loser.[180]

4.150 The IEA concludes that to meet global energy demand and stabilise CO_2 concentrations will require unprecedented technology changes during this century.[181] Potential strategies to avoid one billion tonnes of CO_2 per year (a three per cent difference) as posited by the IEA are listed in table 4.5. For example, to avoid one billion tonnes of CO_2 would require the replacement of 300 conventional 500 MW coal power stations with 1 000 Sleipner carbon sequestration plants (currently being deployed in the North Sea at a cost of US$59/tonne), the installation of 200 times the current US wind generation, or the construction of 1 300 times the current US solar generation. Alternatively, 140 one-gigawatt nuclear power stations would need to be constructed. Dr Ian Smith, Executive Director of ANSTO, argued that 'I believe you have to do all those things; you cannot do just one of those things.'[182]

Table 4.5 Strategies to avoid one billion tonnes of carbon dioxide per year

Coal	Replace 300 conventional, 500-MW coal power plants with 'zero emission' power plants, or …
CO_2 Sequestration	Install 1 000 Sleipner CO2 sequestration plants
Wind	Install 200 times the current US wind generation in lieu of unsequestered coal
Solar PV	Install 1 300 times current US solar generation in lieu of unsequestered coal
Nuclear	Build 140 1-GW power plants in lieu of unsequestered coal plants

Source Claude Mandil, *International Ministerial Conference, Nuclear Power for the 21st Century, March 2005* cited in ANSTO, *Exhibit no. 74, Presentation by Dr Ron Cameron and Dr Ian Smith*, slide no. 30.

179 Mr Mitch Hooke, *op. cit.*, p. 28. FOE and others conceded that 'energy efficiency measures alone are insufficient' to achieve necessary emissions reductions. See: FOE et. al., *op. cit.*, section 6.3.

180 Dr Helen Caldicott, *Exhibit no. 68, op. cit.*, p. ii.

181 Mr Claude Mandil, *loc. cit.*

182 Dr Ian Smith, *op. cit.*, p. 8.

4.151 Silex Systems argued that potential solutions to climate change include a combination of the following:

- decreasing fossil fuel consumption;
- increasing reliance on nuclear power;
- increasing reliance on renewables, at least for peak load power;
- accelerating the hydrogen economy via nuclear power, particularly to replace fossil fuels in transportation; and
- improving energy efficiency.[183]

Silex argued that no one option will solve the greenhouse problem:

> We believe that an integrated mix of nuclear, renewables, hydrogen and energy efficiency measures is required and is inevitable.[184]

4.152 Moreover, in relation to the development of clean coal technologies, development of uranium reserves and renewables/hydrogen, Silex argued that Australia needs a 'bipartisan energy strategy for there to be a coherent and forceful approach. A unique opportunity for political leadership exists'.[185]

4.153 DEH, the MCA and the ANA stressed the importance of addressing GHG emissions by focussing on clean coal technologies given Australia's comparative advantage in coal and the likelihood that the world will remain reliant on fossil fuels, particularly coal, for decades to come:

> … in the longer term the world is going to be reliant on fossil fuels. There is no doubt about that; it is the dominant fuel … So it does make sense to look at technologies by which you can clean up that use of coal in terms of greenhouse emissions.[186]

4.154 DEH emphasised that while uranium exports can reduce emissions if they displace high-intensity sources, Australia has a keen interest in technologies that can produce low emissions from coal and so 'it is in Australia's interests not to set them against each other but to talk about the contribution both can make.'[187] Furthermore, in addition to clean coal technology, it was submitted that Australia has a comparative advantage in solar photovoltaics and hot dry rocks (geothermal) and is best able to contribute in these areas of technology.

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183 Silex System Ltd, *Exhibit no. 88, Presentation by Dr Michael Goldsworthy*, p. 7

184 Dr Michael Goldsworthy, *op. cit.*, p. 3.

185 *ibid*.

186 Mr David Borthwick (DEH), *Transcript of Evidence*, 10 October 2006, pp. 5, 6; MCA, *op. cit.*, p. 10; Dr Clarence Hardy, *op. cit.*, p. 56.

187 Mr Barry Sterland (DEH), *Transcript of Evidence*, 10 October 2005, p. 15.

The limitations of renewable energy sources

4.155 While industry welcomed the contribution that renewable energy sources can make and readily conceded that nuclear power alone could not 'solve' climate change, it was consistently argued that nuclear power is the only low-emission alternative to fossil fuels capable of providing baseload supply of electricity on a large scale. For example, the UIC submitted that:

> While the UIC has a positive view of the role of wind and solar power in the overall electricity supply, we wish to emphasise that the main demand in any urbanised country is for continuous, reliable supply on a large scale, and these intermittent renewables simply cannot meet that, let alone on an economic basis. Nor is there any prospect of them doing so.[188]

4.156 The capacity of nuclear power to provide baseload power with low emissions was emphasised as being particularly important in the context of rapidly growing global energy demand. For example, Paladin Resources argued that:

> It is difficult to see how the world's voracious appetite for energy, and particularly electricity, will be met without compromising greenhouse gas limits unless there is an increasing reliance on nuclear power for baseload, high volume electricity production.[189]

4.157 Similarly, AINSE argued that:

> … of the methods of power generation which contribute least to CO_2 emissions nuclear fission is the only one suited to the provision of a stable baseload … The projected increase in energy demands requires a solution now. Nuclear fission will be one component of multiple strategies, including renewables.[190]

4.158 AMEC also observed that nuclear power is part of the answer to the energy demand and GHG emission problem for the medium term:

> With the growing demand for energy and the dangers that global warming presents … at least in the short to medium term we have to develop uranium deposits throughout this country.[191]

4.159 It was emphasised that renewable energy sources and energy efficiency measures are limited and will not be sufficient to meet growing energy demand and reduce emissions. The SIA argued that the limitations of renewables need to be acknowledged:

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188 UIC, *Submission no. 12.1*, p. 1.

189 Paladin Resources Ltd, *op. cit.*, pp. 5–6.

190 AINSE, *op. cit.*, p. 1.

191 Mr Alan Layton (AMEC), *Transcript of Evidence*, 23 September 2005, p. 21.

> Yes, we must achieve better efficiencies. We must maximise the use of renewable energy—wind, solar and hot rocks—and clean up coal, but we have to be realistic about the risks, the costs and the real limitations of some of these measures. These measures alone will not suffice. The paradox for me is that the very people who would protect the environment have caused and continue to cause such damage by their blind rejection of the realities.[192]

4.160 On the potential for renewables to address global GHG emissions, replace fossil fuels and nuclear power, and meet the growing global demand for energy, CSIRO argued that:

> The question is can renewable technology keep pace with the increasing need for energy? At the moment it does not appear that the technology is advancing at a rate and at a scale that allows it to replace existing fossil fuel and nuclear fuel based energy production … The scenario planning that CSIRO has done so far projects out 50 years or so, and that has fossil fuel based sources of energy still in the mix at that point. At the end of the day, the models must take into account the economic situation as well as the demand situation. It projects increases in electricity production requirements of the order of two per cent growth a year, and we just cannot keep pace with that with any silver bullet technology that might come in.[193]

4.161 Submitters noted that the proportion of world energy demand that will be supplied by renewable sources in the future is highly contested. Nova Energy asserted that without resolving a series of technical challenges, 'there is general acceptance that it will not be possible to meet all future energy demands from renewable energy sources.'[194]

4.162 In general, it was argued that renewable energy sources cannot provide the baseload capacity required by industrial societies and large cities, such as the emerging 'megacities' of Asia.[195] Renewables, such as solar, wind and wave power, were said to be intermittent, provide fluctuating supply and present energy storage issues.[196]

4.163 Nova Energy argued that while renewables are certainly required to complement other energy sources, it is not possible to derive sufficient electricity or liquid fuels from renewables to sustain the present high per

192 Rear Adm. Peter Briggs AO CSC (Retired) (SIA), *Transcript of Evidence*, 10 October 2005, p. 27.

193 Dr Rod Hill (CSIRO), *Transcript of Evidence*, 19 August 2005, p. 5.

194 Nova Energy Ltd, *op. cit.*, p. 23.

195 See for example: Mr John Reynolds, *op. cit.*, p. 3; Compass Resources NL, *op. cit.*, p. 3; Deep Yellow Ltd, *op. cit.*, p. 2.

196 Summit Resources, *op. cit.*, p. 26.

capita rates of consumption, let alone additional growth requirements. The reasons cited for these limitations were:

- Large fluctuations in energy production, for example variability and intermittency of wind energy or limited solar energy efficiency caused by winter solar incidence or night time.
- Need to store energy to cope with timing inconsistencies of supply and demand, for example storage of solar energy for night use. Large storage volumes are required to store significant quantities of energy.
- Significant loss factors during the process, including on transmission, inversion from DC to AC current and conversion for storage.
- Many potential locations from where renewable energy, such as wind, hydro and thermal, may be sourced are significant distances from power grids making transport difficult and expensive.
- Infrastructure requirements are expensive to install and maintain.
- Low efficiency rates, for example solar energy generated compared to actual energy falling on solar panels.
- Current technology requires large amounts of land to house infrastructure.
- It is difficult to extend the use of renewables on a large scale unless significant government policies are implemented, for example reducing carbon-emitting energy sources on the environment and subsidies.
- Renewable energy is not expected to compete economically with fossil fuels in the mid-term forecasts.[197]

4.164 Nova Energy argued that the limitations of wind power are clearly demonstrated by the German experience, which now has over 17 000 wind turbines with capacity exceeding 14 350 MW—the largest installed wind capacity in the world. In 2003, the turbines were said to provide just four percent of Germany's demand for electricity. The operator of Germany's transmission grid, E.ON Netz GmbH, has pointed out that periods of maximum demand often coincide with periods of minimum wind power (for example, summer heatwaves). E.ON estimates that 80 per cent back-up power (nuclear or carbon-based) is required to meet demand at all times. Thus, wind power reduces fossil fuel consumption but does not remove the need for conventional baseload power sources.[198]

4.165 Similarly, Deep Yellow submitted that:

> Evidence to date is that wind, wave and solar power cannot provide the scale of electricity required without a backup facility

197 Nova Energy Ltd, *op. cit.*, p. 24.

198 *ibid.*

> powered by reliable fossil fuels. Geothermal energy is not yet proven on large scales.[199]

4.166 Mr Keith Alder also welcomed the contribution being made by renewables but argued that their limitations needed to be better understood:

> There is a lot of urging that the use of [renewables] be increased—looking for subsidies, of course—from the present one or two per cent up to about 20 per cent … That figure of 20 per cent is one of the limits, I believe. I do not think you can put more than about 20 per cent of renewable energy such as solar and wind into a major electricity grid, for the simple reason that it is unreliable … If the wind does not blow … your wind generator drops out and, if the sun does not shine—and it certainly does not shine at night—you lose your solar energy. There is a natural limit to what the grid can stand. If it drops out and you do not want blackouts, then something else has to pick up the load. No electricity generating authority in the world which believes it can supply reliable energy will tolerate more than about 20 or maybe 30 per cent, at the most, of its input in one piece of machinery. This is why there is a natural limit on the renewables ...[200]

4.167 Mr Alder argued that the key question is:

> … where we get the other 80 per cent. That is where uranium comes into the picture. As far as I can see, there are only two possible ways to generate that 80 per cent, or the baseload—which is more than half and, more likely, 70 per cent—of that 80 per cent. The two alternatives are coal and nuclear; there is nothing else. It is an absolutely inescapable fact that you have to burn coal or use nuclear reactors to generate baseload electricity. You can use oil or gas, but they are both very desirable resources to be retained for other purposes.[201]

4.168 Although opposed to use of nuclear power, AMP CISFT conceded that that renewables cannot meet baseload power requirements, either in Australia or internationally.[202]

4.169 CSIRO submitted that while considerable research is going into energy storage devices for renewables, aside from geothermal there are no renewable sources of energy that provide inherent baseload power.[203] In

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199 Deep Yellow Ltd, *loc. cit.*

200 Mr Keith Alder, *Transcript of Evidence*, 16 September 2005, p. 80.

201 *ibid.*

202 Dr Ian Woods (AMP CISFT), *Transcript of Evidence*, 16 September 2005, p. 34.

203 Dr Rod Hill, *op. cit.*, p. 6. CSIRO also note that the heat content in the granites that could be used for geothermal energy are radiogenic in origin.

surveying the range of future renewable electricity generation options, including photovoltaics, Dr Rod Hill observed that:

> There is certainly a significant research effort in these longer term technologies, but the reality of it is that we need to make the existing dependence on coal more efficient and we need to make sure that people feel comfortable about nuclear, because they are the short-term options.[204]

4.170 The MAPW (WA Branch), who promoted use of renewables such as wind and solar, also conceded that energy storage is a problem for wider deployment of renewables.[205] The ANA also argued that intermittent renewable sources—solar, wind and wave—will not be able to make a major contribution until electricity storage systems are developed to produce a 'smooth, efficient source at reasonable cost. That is the key to renewables.'[206] In the meantime, the ANA expressed support for the Australian Government's efforts to develop clean coal technologies.

4.171 Dr Gavin Mudd observed that geothermal has potential as a future renewable baseload energy source, but being remote from population centres means that significant energy losses can be expected in transmission.[207]

4.172 In summary, Nova Energy argued that:

> … to develop systems in which the majority of energy is sourced from renewables, provision must be made for large fluctuations in energy production and for the need to store large quantities of energy. These problems make a significant difference to the viability of renewables due to the impact on efficiencies and costs.[208]

4.173 Nova Energy also argued that even if renewables could supply baseload power needs, the capital investment that would be required would be 'absolutely enormous'.[209] The UIC also noted that to conform with current German policy, another 30 000 MWe of renewable capacity will need to be added by 2020, which will cost some €80 billion.[210]

4.174 Heathgate Resources pointed to the impracticality of providing baseload power via renewables by comparing the fuel requirements to generate

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204 *ibid.*, p. 11.

205 Dr Stephen Masters (MAPW – WA Branch), *Transcript of Evidence*, 23 September 2005, p. 37.

206 Dr Clarence Hardy, *op. cit.*, p. 56.

207 Dr Gavin Mudd, *Transcript of Evidence*, 19 August 2005, p. 56.

208 Nova Energy Ltd, *loc. cit.*

209 Dr Timothy Sugden (Nova Energy Ltd), *Transcript of Evidence*, 23 September 2005, p. 70.

210 UIC, *Exhibit no. 49, Nuclear Industry in Europe*, p. 3.

1 000 MW, the typical size of a single nuclear reactor, which would require 150 tonnes of natural uranium per year. Given the low energy densities of renewables, to generate this amount of electricity would require 60 to 150 square kilometres of solar panels (in France), 150 to 450 square kilometres of wind mills in a favourable area, 6.2 Mt of garbage, or 4 000 to 6 000 square kilometres of biomass plantations. The fuel requirements for an equivalent capacity fossil fuel plant, discussed above, are 2.3 Mt of coal, 1.9 Mt of oil or 1.4 billion cubic metres of natural gas.[211]

4.175 Concern about the potential of renewables is shared by Dr Mohamed ElBaradei, Director General of the IAEA, who has stated that while nuclear and renewable sources could both have larger roles to play in meeting rising energy demands over coming decades:

> The problem is that no 'renewable' source has been demonstrated to have the capacity to provide the 'baseload' amounts of power needed to replace large fossil fuel plants. Wind power, for example, may be an excellent choice for sparsely populated rural economies, particularly if they lack modern electrical infrastructure; on the other hand, it seems unlikely that wind power will be able to support the electricity needs of tomorrow´s mega-cities.[212]

4.176 Compass Resources argued that as oil production eventually declines, 'the only realistic alternative to meet the increased energy demand is coal or nuclear.'[213] However, it was suggested that despite geosequestration and other improvements, coal is likely to increase greenhouse emissions as demand grows. SIA also argued that geosequestration is 'perhaps 10 years off' and that 'the technical and economic viability have yet to be demonstrated.'[214]

4.177 In addition to comparing the life cycle emissions of electricity generation chains, assessing the contribution that nuclear power can make to GHG abatement necessarily involves an analysis of the costs of generating nuclear power. Although the Committee did not request evidence on this matter, information was provided by some submitters and the Committee presents an overview of this evidence in the section which follows.

211 Heathgate Resources Pty Ltd, *Exhibit no.57, op. cit.*, p. 3.

212 Cited in the Hon Alexander Downer MP, *op. cit.*, p. 7. See also: Dr Mohamed ElBaradei, *Nuclear Power: Preparing for the Future*, 21 March 2005, viewed 12 May 2006, <http://www.iaea.org/NewsCenter/Statements/2005/ebsp2005n004.html>.

213 Compass Resources NL, *op. cit.*, p. 3.

214 SIA, *Submission no. 21*, p. 7.

The economics of nuclear power

4.178 A central consideration in assessing nuclear power's viability as a GHG emission mitigation option relates to the economic attractiveness of nuclear generation of electricity relative to other baseload alternatives.

4.179 The OECD Nuclear Energy Agency (OECD-NEA) states that the economics of nuclear power are characterised by high capital investment costs; low fuel, operating and maintenance costs; insensitivity to variations in fuel prices; and long operational life but significant regulatory costs.[215]

4.180 The costs of producing nuclear electricity are typically broken down into three major categories:

- capital investment costs, including plant construction, major refurbishment and decommissioning;
- operation and maintenance (O&M) costs, including staff costs, training, security, health and safety, and cost of managing low and intermediate level operational waste; and
- fuel cycle costs, including the cost of the uranium, its conversion and enrichment, fuel fabrication, used fuel disposal and reprocessing.[216]

4.181 Capital costs account for approximately 60 per cent or more of the total costs of nuclear electricity production, with O&M and fuel cycle costs accounting for some 20 per cent each of the total cost.[217]

4.182 Compared to nuclear power, coal-fired plants are said to be characterised by mid-range capital and fuel costs, while natural gas-fired plants are characterised by low capital investment costs but significant fuel costs. Renewable sources of energy, such as wind and hydropower, are similar to nuclear in having high capital and low generating costs per unit of power produced.[218]

Studies of the comparative costs of generating electricity

4.183 There have been several respected studies of the economics of nuclear power published in recent years, including the following:

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215 OECD-NEA, *Nuclear Energy Today*, OECD-NEA, Paris, 2003, p. 59, viewed 23 May 2006, <http://www.nea.fr/html/pub/nuclearenergytoday/welcome.html>. See also: MCA, *op. cit.*, p. 10.

216 *ibid.*, p. 60.

217 *ibid.*

218 *ibid.* See also: Dr Ian Smith, *op. cit.*, p. 8; Mr Donald Kennedy (Jindalee Resources Ltd), *Transcript of Evidence*, 23 September 2005, p. 62.

- IEA and OECD-NEA (2005), *Projected Costs of Generating Electricity*[219]
- University of Chicago (2004), *The Economic Future of Nuclear Power*[220]
- Royal Academy of Engineering (2004), *The Cost of Generating Electricity*[221]
- Canadian Energy Research Institute (CERI) (2004), *Levelised Unit Electricity Cost Comparisons of Alternative Technologies for Baseload Generation in Ontario*[222]
- General Directorate for Energy and Raw Materials (DGEMP) of the French Ministry of the Economy, Finance and Industry (2003), *Reference Costs for Power Generation*[223]
- Massachusetts Institute of Technology (MIT) (2003), *The Future of Nuclear Power*[224]

4.184 While these studies come to differing conclusions about the costs of generating nuclear power, in the main they reveal that nuclear power is economically competitive with other baseload alternatives in many countries. This accords with the argument advanced by the MCA, Areva, UIC and others that: 'In many industrialised countries, nuclear energy is cost competitive with coal-fired electricity and gas–fired generation'.[225] The Committee makes observations about the possible economic competitiveness of nuclear power in the Australian context in chapter 12.

4.185 The most recent study, published by the IEA and OECD-NEA, estimated the costs of generating electricity by baseload power plants that are expected to be commercially available by 2015 or earlier. Ten countries submitted data on nuclear plants which were compared with coal and gas generation in the same countries. Some data was also collected on renewable energy generation options.

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219 IEA and OECD-NEA (2005), *Projected Costs of Generating Electricity*, viewed 24 May 2006, <http://www.nea.fr/html/pub/ret.cgi?id=new#5968>.

220 University of Chicago (2004), *The Economic Future of Nuclear Power*, viewed 24 May 2006, <http://www.anl.gov/Special_Reports/>.

221 Royal Academy of Engineering (2004), *The Cost of Generating Electricity*, viewed 24 May 2006 <http://www.nowap.co.uk/docs/generation_costs_report.pdf>.

222 CERI (2004), *Levelised Unit Electricity Cost Comparisons of Alternative Technologies for Baseload Generation in Ontario*, viewed 24 May 2006, <http://www.cna.ca/pdf/CERI_LUEC_Report_August_27_2004-ed.pdf>.

223 DGEMP (2003), *Reference Costs for Power Generation*, viewed 24 May 2006, <http://www.industrie.gouv.fr/energie/electric/cdr-anglais.pdf>.

224 MIT (2003), *The Future of Nuclear Power*, viewed 24 May 2006, <http://web.mit.edu/nuclearpower/>.

225 MCA, *loc. cit*. UIC, *The Economics of Nuclear Power*, Briefing Paper No. 8, April 2006, viewed 24 May 2006, <http://www.uic.com.au/nip08.htm>.

4.186 The principal findings, which include the average plant construction costs, average construction times and levelised electricity generation costs for the electricity generation options employed in the survey countries are listed in table 4.6. The levelised generation cost figures incorporate capital, O&M and fuel costs relevant to each technology. The levelised cost is the price needed to cover both the operating (fuel and O&M) and annualised capital costs of a plant. The calculations do not include costs of transmission and distribution, or costs associated with residual emissions including greenhouse gases from coal and gas-fired plants.

Table 4.6 Construction costs, construction time and levelised costs of electricity generation

Generating technologies	**Construction costs** (per plant, US$/kWe)	**Construction time** (years)	**Levelised generation costs** (US$/MWh @ 5% discount rate)	**Levelised generation costs** (US$/MWh @ 10% discount rate)
Coal-fired	1 000 – 1 500	4	25 – 50	35 – 60
Gas-fired	400 – 800	2 – 3	37 – 60	40 – 63
Nuclear	1 000 – 2 000	5	21 – 31	30 – 50
Wind (onshore)	1 000 – 2 000	1 – 2	35 – 95	45 – >140*
Solar	2 775 – 10 164	1	~150	>200
Hydro	1 500 – 7 000	3	40 – 80	65 – 100

Source IEA and OECD-NEA, *Projected Costs of Generating Electricity: 2005 Update*
* Does not include specific costs associated with wind or other intermittent renewable energy source for power generation, such as the need for backup power to compensate for the low average availability factor

4.187 The study found that despite relatively high capital costs, nuclear power is competitive with fossil fuels for electricity generation in many countries. Construction costs for nuclear power plants range from US$1 000 per kW in the Czech Republic to $2 500 per kW in Japan. Coal-fired plants range from $1 000 to $1 500 per kW and gas-fired plants are significantly less costly at between $400 and $800 per kW.[226]

4.188 At the five per cent discount rate, nuclear power is revealed to be generally the lowest cost option with costs ranging from US$21 to $31 per MWh. Nuclear is cheaper than coal in seven of the ten countries and cheaper than gas in nine. The lowest costs for nuclear production were recorded in Korea, the Czech Republic, Canada and France and the highest in Japan. At the 10 per cent discount rate, the levelised costs for nuclear range from $30 to $50 per MWh. Despite this, nuclear is cheaper than coal in five of the ten countries and cheaper than gas in eight.[227]

4.189 DEH expressed some reservations about the cost estimates, cautioning that the study fails to specify the level of finance allocated to

226 IEA and OECD-NEA, *op. cit*., pp. 43, 35, 39.

227 *ibid*., p. 47.

decommissioning (although the estimates do explicitly incorporate decommissioning costs). The study was also criticised for not including complete insurance risk and the cost of permanent waste storage, which it was argued 'may raise the levelised cost considerably'.[228]

4.190 The IEA and OECD-NEA make clear that although the cost estimates do not substitute for detailed economic evaluations required by investors and utilities at the stage of project decision and do not take business risks in competitive markets adequately into account, nonetheless they 'provide a robust, transparent and coherent set of cost estimates … and may be used to assess alternative options at the stage of screening studies.'[229]

4.191 The IEA and OECD-NEA concluded that the generating technology preferred in each country will depend on the specific circumstances of each project. Further, the ranking of technologies in each country is sensitive to the discount rate employed and the projected prices of natural gas and coal.[230]

4.192 DEH also argued that the cost of electricity from nuclear compared to coal will vary according to 'the generation plant's proximity to its fuels source, the quality of fuel and the age of competing infrastructure.'[231]

4.193 The UIC and the MCA observed that the comparative costs of nuclear and coal depends on the locality of the proposed plant. If a power station is far removed from sources of coal and global transport is required then nuclear becomes more attractive.[232] Similarly, AMEC observed that nuclear is competitive with other forms of electricity generation, except where local access to low cost fossil fuels exist.[233]

4.194 The study by the Royal Academy of Engineering (2004), *The Costs of Generating Electricity*, compared the present day costs of generating electricity in the UK from available technologies, including coal, oil, gas, nuclear, wind and biomass. The study considered what was regarded as best estimates of what it costs to build, maintain and operate various power stations. That is, the study incorporated the costs of construction, O&M and fuel for each plant. It also included an estimate of decommissioning costs for nuclear plants, but assumed that decommissioning costs for other plants are neutral. The study's findings are depicted in figure 4.3.

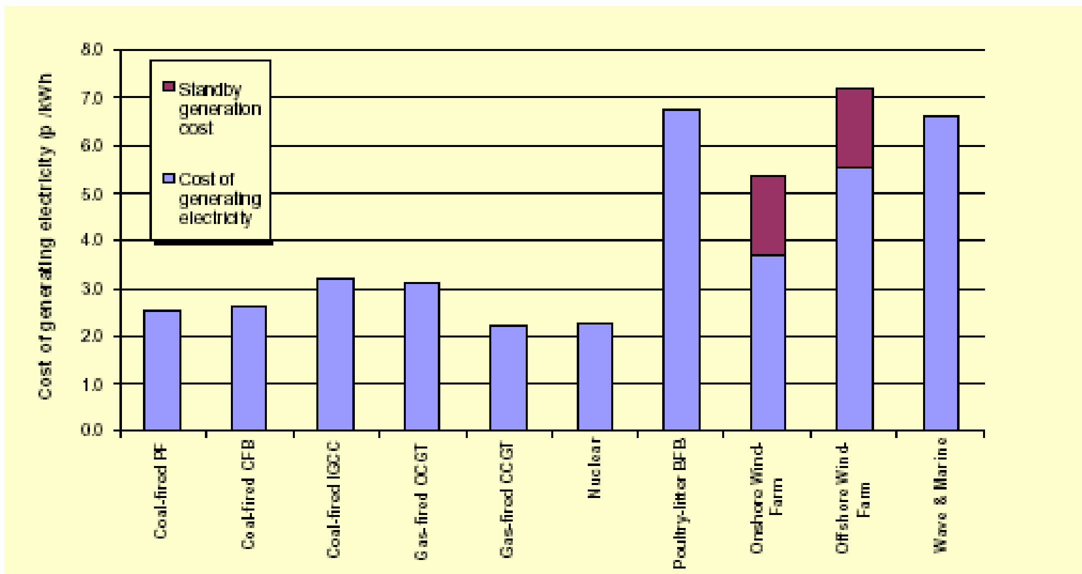
228 DEH, *loc. cit.*
229 IEA and OECD-NEA, *op. cit.*, p. 16.
230 *ibid.*, p. 14.
231 DEH, *op. cit.*, p. 6.
232 Mr Robert Rawson (MCA), *Transcript of Evidence*, 5 September 2005, p. 31.
233 AMEC, *op. cit.*, p. 6.

4.195 The study concluded that for baseload operation, generating costs are 2.2 pence per kWh for combined-cycle gas turbine (CCGT) plants, 2.3 pence per kWh for nuclear plants and between 2.5 and 3.2 pence per kWh for coal plants.[234]

4.196 Renewable energy sources, which offer intermittent power, were found to be markedly more expensive, with onshore wind generation costing 3.7 pence per kWh and offshore wind costing 5.5 pence per kWh. However, when the additional cost of standby generation was added, the costs became 5.4 and 7.2 pence per kWh respectively.[235] The effect of including standby generation costs is also depicted in figure 4.3.

4.197 The Academy's study also examined the sensitivity of electricity generation costs to variations in fuel prices and emission costs. As the cost of carbon emissions increases, nuclear and renewables become more competitive and the gap between CCGT plants and coal-fired technologies widens (because of the greater level of carbon found in coal compared with natural gas and the lower efficiency of steam plant). It was found that if fuel prices rise by 20 per cent or carbon taxes are introduced, nuclear becomes the cheapest option to deploy.[236]

Figure 4.3 Cost of generating electricity (pence per kWh) in the UK



Source The Royal Academy of Engineering, *The Costs of Generating Electricity*, p. 4.

234 Royal Academy of Engineering, *op. cit.*, p. 5.
235 *ibid.*, p. 6.
236 *ibid.*, p. 7.

4.198 The University of Chicago (2004) study, *The Economic Future of Nuclear Power*, which was sponsored by the US DOE, found that new nuclear plants coming online in the next decade will initially have a levelised cost of electricity of US$47 to $71 per MWh. In comparison, coal plants will be in the range of $33 to $41 per MWh and gas-fired plants will be in the range of $35 to $45 per MWh. However, it was found that once early costs are absorbed, levelised costs for nuclear plants will fall to the range of $31 to $46 per MWh.[237] Thus, the DOE concluded that 'the future cost associated with nuclear power production is comparable with gas and coal-based energy generation', and that 'nuclear power can be a competitive source of energy production in the future and will help meet our environmental goals.'[238]

4.199 The CERI (2004) study, *Levelised Unit Electricity Cost Comparisons of Alternative Technologies for Baseload Generation in Ontario,* found that in the majority of scenarios considered, coal-fired generation is the most attractive option. However, if CO_2 emission costs of C$15 per tonne are included, deployment of 'first of a kind' nuclear technology (the twin ACR-700 reactor) becomes either the least-cost generating option or competitive with coal-fired generation depending on financing assumptions. For later deployments of the technology, cost savings are expected to reduce the levelised cost so that nuclear is competitive with coal even in the absence of CO_2 emission costs. Given forecast increases in the price of natural gas, gas-fired generation for baseload supply was found to be uncompetitive in most scenarios considered.[239]

4.200 The DGEMP study (2003), *Reference Costs for Power Generation*, found that using an eight per cent discount rate, nuclear power will be the cheapest option at 2.84 euro cents per kWh, followed by coal plants at 3.37 euro cents per kWh and the CCGT at 3.50 euro cents per kWh. At higher discount rates, nuclear's advantage is reduced. Nuclear power's competitiveness improves even further if CO_2 emission costs are included. Figure 4.4 illustrates the main conclusions of the study, showing the basic costs of the technologies estimated for 2015 and the effect of additional CO_2 costs.[240]

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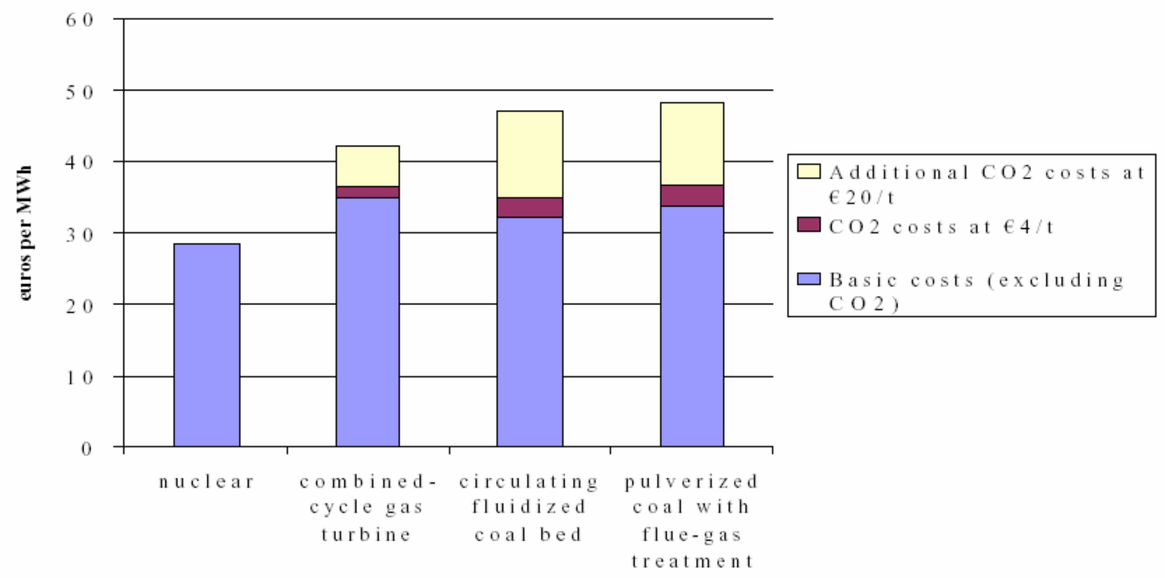
237 University of Chicago, *op. cit.*, pp. xi–xii.

238 Argonne National Laboratories, *Study shows future cost of nuclear power is comparable with gas- and coal-fired energy*, Media Release, 20 September 2004, viewed 25 May 2006, <http://www.anl.gov/Special_Reports/>.

239 CERI, *op. cit.*, pp. 3–4.

240 DGEMP, *op. cit.*, p. 2.

Figure 4.4 Costs (including tax) of baseload alternatives in France in 2015, based on an 8 per cent discount rate and showing CO_2 costs



Source DGEMP, *Reference Costs for Power Generation*, p. 1.

4.201 In contrast to the generally positive assessments of nuclear power's economic competitiveness in the studies summarised above, the MIT study (2003), *The Future of Nuclear Power,* found nuclear power to be an unattractive option. The study, which used construction and financing cost assumptions the industry considers demanding for nuclear, found the levelised cost for nuclear power to be US6.7 cents per kWh, compared to 3.8 to 5.1 cents per kWh for gas and 4.2 cents per KWh for coal.[241]

4.202 Even with the imposition of a cost for CO_2 emissions of US$50 per tonne of carbon (tC), nuclear power was still found to be uncompetitive against gas and coal in a base case scenario. With carbon taxes in the range of $100/tC to $200/tC, nuclear power would be an economic baseload option.[242]

4.203 DEH stated that, as with the IEA and OECD-NEA study, it was unclear whether MIT accounts for the costs of decommissioning, insurance risk and permanent waste disposal. Again, these factors could raise the levelised cost considerably.[243]

4.204 Notwithstanding its conclusion that nuclear 'is just too expensive', particularly in regions where electricity suppliers have access to natural gas or coal, the MIT study concluded that:

241 For a plant with a 40 year life and 85 per cent capacity factor. MIT, *op. cit.*, p. 42. WNA, *The New Economics of Nuclear Power*, WNA, London, December 2005, p. 25, viewed 24 May 2006, <http://www.uic.com.au/neweconomics.pdf>.

242 MIT, *loc. cit.*

243 DEH, *loc. cit.*

> If in the future carbon dioxide emissions carry a significant 'price' … nuclear power could be an important—indeed vital—option for generating electricity … *we believe the nuclear option should be retained, precisely because it is an important carbon-free source that can potentially make a significant contribution to future electricity supply.*[244]

Reducing capital costs

4.205 In relation to the high capital costs for nuclear plants, ANSTO observed that efforts are now being made, for example through the 'Nuclear Power 2010' initiative in the US, to reduce capital costs, including by establishing more efficient licensing and approvals processes.[245]

4.206 Technological developments in reactor designs are also promising to reduce construction costs and construction times. For instance, ANSTO noted that 'pebble bed' reactors, which are fourth generation designs, are intended to be modular; that is, of various sizes from, say, 180 MW upwards. The costs for these reactors, which are thought to be appropriate for desalination and to supply power in remote communities, will be a fraction of the cost of a large 1 000 MW reactor, roughly proportional to the amount of power they produce. Thus, a 100 MW reactor would cost in the order of $250 million to construct.[246]

4.207 According to information published by academics from the School of Physics at the University of Melbourne, Westinghouse claims that its advanced reactor, the AP1000, will cost US$1 400 per KWh for the first reactor and fall to $1 000 for subsequent reactors. It is also claimed that the AP1000 would take only three years to construct. For the Melbourne University group:

> If the AP1000 lives up to its promise of $1000 per KW construction cost and 3 year construction time, it will provide cheaper electricity than any other Fossil Fuel based generating facility, including Australian Coal power, even with no sequestration charges.[247]

4.208 In addition to new and simpler reactor designs and more predictable licensing processes, the WNA has suggested that other areas of potential capital cost reductions include: replicating several reactors of one design on one site, which can bring major unit cost reductions; standardisation of

244 MIT, *op. cit.*, pp. 40–41, 3. Emphasis in original.
245 Dr Ron Cameron, *op. cit.*, pp. 9, 10.
246 *ibid.*, p. 14.
247 Nuclearinfo.net, *loc. cit.*

reactors and construction in series; and larger unit capacities which provide substantial economies of scale.[248]

Low operating costs

4.209 ANSTO and the AMP CISFT argued that one of nuclear power's clear advantages is low operating (i.e. fuel and O&M) costs. For example, in the US operating costs for nuclear plants continue to decline and in 2004 were US1.72c per kWh, slightly lower than coal at 1.8c per kWh and substantially lower than oil at 5.53c per kWh and gas at 5.77c per kWh. The operating costs for oil and gas were said to have increased substantially in recent times.[249]

4.210 Cameco also observed that 'from a cost perspective, nuclear power has been the lowest cost generator of electricity in the United States for four years running, marginally under coal, with one exception—that is, hydro-generated electricity'.[250]

4.211 Table 4.7 lists the comparative operating costs for nuclear, coal and gas generation for a range of countries projected for 2010 onwards, produced by the IEA and OECD-NEA. The data forecasts that costs of nuclear power will be below those for coal and gas in all countries, except the US and Korea where the cost of nuclear will exceed that of coal by a small margin. Costs for coal and gas generation in Australia have been included for an indicative rather than direct comparison. ANSTO observed that operating costs vary depending on whether a country has indigenous supplies of the particular fuel, the cost of importation and the cost of a country's regulatory systems.

4.212 A key factor in nuclear power's improved competitiveness has been a steady increase in nuclear plant availability and productivity. In particular, nuclear generating capacity has improved markedly in recent years. In 1990, nuclear plants on average were generating electricity 71 per cent of the time, but by 2005 reactor capacity reached a record average of 91.5 per cent in the US.[251] According to the IAEA, the global increase in generating capacity over the past 15 years represents 'an improvement in productivity equal to adding more than 25 new 1 000 megawatt nuclear plants—all at relatively minimal cost.'[252]

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248 WNA, *The New Economics of Nuclear Power*, *op. cit.*, p. 19.

249 ANSTO, *Exhibit no. 74, Presentation by Dr Ron Cameron and Dr Ian Smith*, p. 11; AMP CISFT, *Exhibit no. 65, op. cit.*, p. 14.

250 Mr Jerry Grandey, *op. cit.*, p. 7.

251 Professor Leslie Kemeny, *Exhibit no. 9, Power to the people*, p. 2.

252 Dr Mohamed ElBaradei, *Nuclear Power: Preparing for the Future*, 21 March 2005, viewed 12 May 2006, <http://www.iaea.org/NewsCenter/Statements/2005/ebsp2005n004.html>.

Table 4.7 Comparative electricity production cost projections for 2010 onwards (US 2003 cents per kWh)

Country	Nuclear	Coal	Gas
Finland	2.76	3.64	—
France	2.54	3.33	3.92
Germany	2.86	3.52	4.90
Switzerland	2.88	—	4.36
Netherlands	3.58	—	6.04
Czech Republic	2.30	2.94	4.97
Slovakia	3.13	4.78	5.59
Romania	3.06	4.55	—
Japan	4.80	4.95	5.21
Korea	2.34	2.16	4.65
USA	3.01	2.71	4.67
Canada	2.60	3.11	4.00
Australia*	—	3.00 – 3.50 (black coal) 3.60 – 4.00 (brown coal)	3.50 – 4.50

Source ANSTO, *Exhibit no. 74, Presentation by Dr Ron Cameron and Dr Ian Smith*, slide 12; ANSTO, *Submission no. 29.1*, p. 3.
US 2003 cents/kWh, Discount rate 5%, 40 year lifetime, 85% load factor
* Australian cents per kWh in 2010.

4.213 Additional generating capacity has also been obtained through up-rating the power output of nuclear reactors, by up to 15–20 per cent in some cases. This has been a particular focus in the US, Sweden and Eastern European countries. Owners of nuclear plants are also seeking to obtain permission from regulatory authorities to extend the operational life of their plants, thereby generating additional output per plant. In the US, 30 nuclear plants have already been granted 20-year life extensions.[253]

Electricity price stability

4.214 In general, fuel costs represent a relatively large proportion of fossil fuel-based generating costs that are, as a result, sensitive to fuel price variations. Areva submitted that this is one of nuclear power's main advantages over other baseload alternatives: nuclear power has low fuel costs as a proportion of the overall cost of the electricity production, which means that the price of nuclear electricity is insensitive to fuel price rises and therefore relatively stable:

> … unlike its fossil fuel competitors, nuclear power is relatively immune to changes in fuel prices, which represent approximately

253 WNA, *The New Economics of Nuclear Power*, *op. cit.*, p. 12.

> 15% of its production cost. Based on current prices, natural uranium itself represents approximately 5% of the cost of nuclear electricity.[254]

4.215 Drawing on a Finnish study published in 2004, Areva argued that:

> … a 50% increase in the cost of natural uranium would raise the cost of nuclear generated electricity from €23.70 to €24.30. A 50% increase in the cost of natural gas or coal would raise the cost of electricity produced with these sources of energy from €31.20 to €42.40 for natural gas and from €32.90 to €41.85 for coal.[255]

4.216 Similarly, the AMP CISFT argued that:

> … doubling the price of uranium would increase the cost of [nuclear] power plant electricity by 20%. Doubling the price of coal would increase coal power plant electricity by 58%. The figure is 90% for gas power plants.[256]

External costs — carbon dioxide emissions, waste management and decommissioning

4.217 The UIC explained that external costs are those which are actually incurred in relation to the health and the environment but not paid directly by the electricity producer or consumer.[257] For fossil fuel plants these externalities include the unpriced costs of carbon dioxide emissions into the atmosphere.

4.218 It was argued that, unlike nuclear power, the environmental costs of fossil fuel power generation are not factored into the cost of the electricity produced.[258] Thus, if the external costs of carbon emissions into the atmosphere were internalised in fossil-fuel electricity generation through the imposition of a carbon tax, the economic competitiveness of nuclear power could improve significantly.[259]

4.219 Several of the studies cited above noted that the introduction of a cost of carbon emissions (e.g. carbon taxes) would raise the levelised cost of fossil fuel electricity generation and thereby enhance the competitiveness of nuclear power, rendering nuclear the lowest cost option in many cases.

4.220 The UIC argued that international pressure will continue for limits to be imposed on carbon emissions and for costs of carbon to be internalised:

254 Areva, *op. cit.*, p. 5.

255 *ibid*.

256 AMP CISFT, *Exhibit no. 65, op. cit.*, p. 14.

257 UIC, *Nuclear Electricity*, Chapter 2, viewed 28 May 2006, <http://www.uic.com.au/ne2.htm>.

258 Mr Richard Pearce, *op. cit.*, p. 81.

259 OECD-NEA, *op. cit.*, p. 63.

> Inevitably, international pressure will continue for limits to be imposed. In the context of the Kyoto Protocol, a carbon cost of at least one US cent per kWh needs to be factored for coal generation, and at least half that for gas (on the basis of various proposals and European Union Emissions Trading Scheme transactions). This would effectively increase costs by 20 to 30%. By comparison, nuclear energy has zero cost for carbon emissions.[260]

4.221 ANSTO noted that studies of the effects of carbon emissions trading on electricity generating costs in Finland have rendered nuclear power far more competitive than gas and coal, with the costs of nuclear approximately €20 per MW compared to more than €40 per MW for coal. This calculation was said to be significant in Finland's decision to proceed with a nuclear power program.[261]

4.222 The UIC also cited a major study of the other external costs of various fuel cycles published by the European Commission in 2001. The study found that if other external costs were included, the price of electricity from coal would double and the price of electricity from gas would increase by 30 per cent.[262]

4.223 AMP CISFT argued that without imposing a substantial cost of carbon, nuclear power will remain uneconomic.[263] However, from the industry's perspective, the UIC and WNA argued that nuclear power is already economically competitive in many countries, even without factoring in a cost of carbon or considering nuclear's advantages of price stability and security of supply:

> In most industrialised countries today, new nuclear power plants offer the most economical way to generate base-load electricity—even without consideration of the geopolitical and environmental advantages that nuclear energy confers.[264]

4.224 The UIC argued that the cost of waste management (including eventual disposal) and decommissioning old reactors are internalised in power prices charged by nuclear utilities during the operational life of each plant. The back-end of the nuclear fuel cycle, including used fuel storage or disposal in a repository, contributes some 10 per cent of the overall cost of the electricity generated. Decommissioning plants is said to cost approximately 5 per cent of the total generating cost.[265]

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260 UIC, *op. cit.*, p. 14.

261 Dr Ron Cameron, *op. cit.*, p. 5.

262 UIC, *The Economics of Nuclear Power, loc. cit.*

263 Dr Ian Woods (AMP CISFT), *Transcript of Evidence*, 16 September 2005, p. 30.

264 WNA, *The New Economics of Nuclear Power*, *op. cit.*, p. 6; UIC, *loc. cit.*

265 UIC, *Submission no. 12*, p. 15.

4.225 As discussed further in the following chapter, the costs of nuclear waste disposal and decommissioning are funded by a levy on nuclear utilities which is set at 0.1 to 0.2 cents per kWh in the US and at similar levels in European countries. To date, more than US$28 billion has been committed to the US Nuclear Waste Fund by nuclear utilities.[266]

4.226 In contrast, the AMP CISFT argued that the operating costs of nuclear power plants do not include the costs for 'acceptable' waste disposal of the low and high level wastes produced. AMP CISFT claimed that the impact of waste disposal costs on the economics of nuclear power is illustrated in the UK where, it is asserted, British Energy (BE) is in financial difficulty due to the need to pay £300 million per year to British Nuclear Fuels (BNFL) for fuel reprocessing. Furthermore, it was argued that BE is unable to pay for plant decommissioning by internal sources, which is estimated to cost some £14 billion over future years. Similarly, AMP CISFT argued that the US Government is paying US$58 billion to develop the Yucca Mountain nuclear waste storage facility, but that 'it will take … 50 years before the nuclear power industry will collect enough to pay for the Yucca Mountain site.'[267]

Opportunity costs

4.227 Submitters that were critical of nuclear power cited studies which claimed that 'alternative energy sources [are] three to four times less costly as a means of reducing carbon dioxide than nuclear power.'[268] These submitters asserted that investment in nuclear power would reduce the amount of investment available for renewables and efficiency measures, and therefore worsen climate change because of the alleged opportunity cost this would involve.[269] For example, People for Nuclear Disarmament NSW argued that:

> In theory, nuclear expansion could proceed in tandem with concerted efforts in the areas of energy efficiency and renewable energy sources. In practice, nuclear expansion would most likely divert social and economic resources away from efficiency and renewables.[270]

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266 *ibid.*, pp. 15, 22, 40.

267 AMP CISFT, *Exhibit no. 65, op. cit.*, pp. 18, 14.

268 Dr Gary Scott, *op. cit.*, p. 4. See also: MAPW (Victorian Branch), *loc. cit.* The CFMEU also argued that: 'At best, nuclear power will be a modest but risky and expensive contributor to the problem of addressing climate change', *Submission no. 26*, p. 4.

269 See for example: NT Greens, *Submission no. 9*, p. 1; MAPW (WA Branch), *op. cit.*, p. 5l; PHA, *loc. cit*; Mr Colin Mitchell, *Submission no. 67*, p. 1.

270 People for Nuclear Disarmament NSW Inc, *op. cit.*, p. 6.

4.228 Research cited by Dr Helen Caldicott emphasised that use of nuclear power to address climate change would involve opportunity costs, asserting that nuclear power is the most costly option for prevention of climate change. It was argued that nuclear power has a higher cost per unit of CO_2 abated than its 'decentralised rivals', which 'means that every dollar invested in nuclear expansion will *worsen* climate change by buying less solution per dollar.'[271] That is, investment in nuclear power involves significant opportunity costs:

> Specifically, every $0.10 spent to buy a single new nuclear kilowatt-hour … could instead have bought 1.2 to 1.7 kWh of windpower … 0.9 to 1.7+ kWh of gas-fired industrial or ~2.2–6.5+ kWh of building-scale cogeneration …, an infinite number of kWh from waste-heat cogeneration …, or at least several, perhaps upwards of ten, kWh of electrical savings from more efficient use. In this sense of 'opportunity cost'—any investment foregoes other outcomes that could have been bought with the same money—nuclear power is far *more* carbon-intensive than a coal plant.[272]

4.229 AMP CISFT also argued that to address greenhouse gas emissions, on an opportunity cost basis, funds should be invested in alternative energy industries rather than nuclear power.[273]

4.230 In contrast, the studies cited above concluded that renewables, particularly wind, have consistently higher generation costs than nuclear plants. These costs are even higher if the necessity for standby generation is included (because of the intermittent nature of renewable electricity). The UIC stated that:

> Wind power, the main no-carbon alternative to nuclear, typically costs significantly more per kWh generated with its unpredictable availability requiring additional investment in back-up capacity.[274]

Subsidies

4.231 Critics of nuclear power argued that the industry is heavily subsidised. For example, the MAPW (Victorian Branch) argued that:

> Nuclear power is one of the most protected and heavily-subsidised industries in the world, and many cost estimates from proponents fail to take these into account. In the mid-1990s, governments

271 Dr Helen Caldicott, *Exhibit no. 68*, *loc. cit*. Emphasis in original.

272 *ibid*.

273 Dr Ian Woods, *op. cit*., p. 33.

274 UIC, *Submission no. 12*, p. 14. See also: Institute of Public Affairs, *Exhibit no. 46, The Economics of Nuclear Power*, p. 1.

> worldwide were subsidizing fossil fuels and nuclear power to the tune of US$250-300 billion per annum. While several transitional and developing country governments have since reduced energy subsidies substantially, global subsidies for conventional (fossil fuel and nuclear) energy remain many magnitudes higher than those for benign alternatives such as efficiency and renewables.[275]

4.232 Similarly, the AMP CISFT argued that the nuclear power industry is subsidised by government for its negative externalities, discussed above, of waste disposal and decommissioning. An example cited was the British Government's payments to BE, via an emergency loan, for waste disposal costs in the order of £184 million a year:

> If you do the calculation, you find that is equivalent to a subsidy of about £2.50 per megawatt hour produced, or about $A5. The industry—BNFL—in its publication say that the cost of waste disposal is only £0.80, so already there is an inconsistency between what is required for the government to subsidise waste disposal as opposed to what a proponent of the industry says is required.[276]

4.233 Research cited by Dr Helen Caldicott asserts that the US *Energy Policy Act 2005* is 'festooned with lavish subsidies and regulatory short cuts for favoured technologies that can't compete unaided.'[277] It is argued that the Act contains some US$13 billion in subsidies to support nuclear expansion, including loan guarantees, research and development support, licensing-cost subsidies, public insurance against regulatory delays, an increase in operating subsidies, tax breaks for decommissioning funds and a cap on liability payments in case of accidents.[278]

4.234 The ECNT alleged that during the first 15 years of development in the US, the nuclear power industry received subsidies amounting to $15.30 per kWh, while the wind industry received 46c per kWh in its first 15 years of operation. It was argued that 'these huge imbalances towards dangerous, polluting and greenhouse intensive fuels need to be urgently addressed.'[279]

4.235 However, the WNA has flatly rejected that the nuclear power industry requires subsidies to be viable:

> Nuclear power does not, as critics often allege, depend on subsidies to be economically sustainable. Fossil fuels benefit from

275 MAPW (Victorian Branch), *op. cit.*, p. 10. See also:
276 Dr Ian Woods, *op. cit.*, p. 29.
277 Dr Helen Caldicott, *Exhibit no. 68*, *op. cit.*, p. 16.
278 *ibid.*, pp. 16-17.
279 Dr Gary Scott, *op. cit.*, p. 4.

> direct subsidies in some countries (like coal in Germany) or from hidden subsidies in the form of pollution and other external costs not taken into account.[280]

4.236 As noted above, some submitters, including the ECNT and Uniting Church in Australia (Victoria and Tasmanian Synod) urged the Australian Government to significantly increase the provision of subsidies for research, development and implementation of renewables. However, the ANA and other submitters observed that renewables currently require large subsidies in order to increase adoption.[281] The AMP CISFT conceded that without subsidies, investments in renewables would not be attractive.[282]

4.237 The UIC noted that renewable capacity in Germany has risen to 17 GWe due to generous subsidies, with the actual cost of wind generation 7–9 Euro cents per kWh (double the cost of nuclear and coal) and requires a 6.2c per kWh average subsidy through a feed-in tariff.[283]

4.238 The UIC observed that if subsidies and other government incentives are provided to renewables in order to achieve lower carbon emissions, then these incentives:

> … should be applied to anything which achieves low carbon emissions and not … discriminating against nuclear power. In other words, if subsidies are available for wind in Australia, on the basis of carbon reduction, they should be equally available to nuclear.[284]

280 WNA, *The environment needs nuclear*, *loc. cit*.
281 Dr Clarence Hardy, *op. cit*., p. 56.
282 Dr Ian Woods, *op. cit*., p. 33.
283 UIC, *Exhibit no. 49, loc. cit*.
284 Mr Ian Hore-Lacy, *op. cit*., p. 90.

Conclusions

Greenhouse gas mitigation

4.239 The Committee concludes that nuclear power unquestionably makes a significant contribution to the mitigation of GHG emissions—nuclear power plants currently save some 10 per cent of total CO_2 emissions from world energy use. This represents an immense saving of GHG emissions that would otherwise be contributing to global warming. If the world were not using nuclear power plants, emissions of CO_2 would be some 2.5 billion tonnes higher per year.

4.240 Australia's uranium exports displace some 395 million tonnes of CO_2 each year, relative to black coal generation, and this represents some 70 per cent of Australia's total GHG emissions for 2003. Evidence suggests that the cumulative carbon savings from nuclear power over the three decades to 2030 will exceed 25 billion tonnes.

4.241 In addition to its GHG mitigation benefits, nuclear power also offsets the vast emissions of sulphur dioxide, nitrous oxide and particulates which are produced by fossil fuelled plants.

4.242 The Committee notes the support shown for nuclear power by several foundational figures of the environment movement. These individuals now perceive that the risks of expanded use of nuclear power are insignificant in comparison to the threat posed by the enhanced greenhouse effect and global warming. The Committee notes calls by some in industry that, in view of the energy demands from heavily populated developing nations, Australia in fact has a moral responsibility to contribute to reducing global GHG emissions through the increased production and supply of uranium.

4.243 It was claimed that nuclear power will not solve climate change because it only reduces emissions from the electricity sector, which is only one source of anthropogenic GHG emissions. The Committee notes, however, that no representative of the uranium industry ever claimed that nuclear power alone could 'solve' climate change. In fact, it was repeatedly stated that nuclear power is one, albeit significant, part of the solution to global warming.

4.244 Although nuclear power has the potential to reduce emissions in the transport sector through the production of hydrogen, nuclear's greenhouse mitigation contribution is currently limited to the electricity sector. However, electricity generation, which is already the largest contributor of CO_2 emissions at 40 per cent of the global total, is also the fastest growing. It is imperative that emissions from this sector be reduced.

4.245 The Committee finds that over its whole fuel cycle nuclear power emits very small quantities of CO_2—orders of magnitude less than fossil fuels and quantities similar to, or less than, renewable such as wind.

4.246 Evidence suggests that renewables and energy efficiency measures alone have no prospect of meeting rapidly growing demands for energy and abating greenhouse emissions to the degree required. The weight of evidence points to the need for a mix of low-emission energy sources and technologies, in which nuclear power will continue to play a significant part.

4.247 In the context of rapidly growing energy demand, particularly from developing nations, nuclear power represents the only means of limiting increased emissions while meeting the world's voracious appetite for energy. While the Committee recognises that there is a role for renewables and certainly for greater use of efficiency measures, renewables are limited in their application by being intermittent, diffuse and pose significant energy storage problems. Renewables also require substantial backup generation, which needs to be provided by conventional baseload power sources. Promised baseload contributions from geothermal, which will be welcome, are yet to be developed on any scale.

4.248 The Committee believes that the nuclear versus renewables dichotomy, which is explicit in some submissions, is a false debate and misses the point: while renewables have a contribution to make, other than hydro and (potentially) geothermal, they are simply not capable of providing baseload power on a large scale. The relevant comparison, if one needs to be made, is between baseload alternatives. On this issue the evidence is clear—nuclear power is the only proven technology for baseload power supply which does not release substantial amounts of CO_2.

4.249 The Committee also recognises that given its comparative advantage in fossil fuels and the world's projected continued reliance on fossil fuels, Australia has a strong economic interest in supporting technologies that reduce the greenhouse intensity of these fuels. The Committee agrees that nuclear power should not be seen as competing with or substituting for clean coal technologies, and indeed renewables such as photovoltaics in which Australia has expertise.

Economics

4.250 A vital consideration in assessing nuclear power's viability as a GHG emission mitigation option relates to the economic competitiveness of nuclear power relative to other baseload alternatives. Evidence suggests that nuclear power plants have higher capital/construction costs than either coal or gas plants, which are characterised by mid-range and low capital costs respectively. However, nuclear plants have low fuel, operating and maintenance costs relative to the fossil fuel alternatives.

4.251 A range of recent studies have concluded that, in many industrialised countries, nuclear power is competitive with gas and coal-fired electricity generation, even without incorporating an additional cost for the carbon emissions from the fossil fuelled plants. Factors that influence the suitability of deploying nuclear plants in a particular situation include the projected prices of natural gas and coal, the discount rate employed, proximity and access to fuel sources such as low cost fossil fuels, and the quality of fuel sources.

4.252 Although nuclear plants generally have higher capital costs, the Committee notes there are developments which promise to reduce the construction costs and construction times for new plants, including possible regulatory reforms in the US and new plant designs. It seems clear that replicating several reactors of one design, or standardising reactors, reduces levelised generating costs considerably.

4.253 Although again the Committee does not wish to enter into a nuclear versus renewables debate, evidence suggests that renewables, particularly wind, have consistently higher generating costs than nuclear plants. These costs are even higher if the necessity for standby generation is included.

4.254 The Committee concludes that, in addition to security of energy supply and near-zero GHG emissions, nuclear power offers at least three economic advantages relative to other baseload energy sources:

- price stability, because the price of nuclear generated electricity is largely insensitive to variations in fuel prices;
- very low operating costs—consistently lower even than coal in the US; and
- internalisation of costs that are not incorporated in the cost of other sources of electricity, notably waste management.

4.255 Although the Committee is not in a position to assess the veracity of claims about subsidies received by the industry, claims by some submitters that the cost of decommissioning and waste disposal are not included in economic assessments of nuclear power or the price of its electricity are entirely mistaken. Unlike its fossil fuel alternatives, nuclear utilities are required to set aside funds to cover decommissioning and final waste disposal. While the adequacy of the funds set aside may be queried, there can be no question that these costs are internalised in the price of the electricity generated.

4.256 The Committee notes that if fossil fuel plants were required to internalise the environmental costs of their emissions (for example, if a cost of carbon were imposed), this would undoubtedly effect the cost of the electricity generated and could significantly improve the economic competitiveness of nuclear power, even in countries with plentiful supplies of low cost fossil fuels.

4.257 The issue of waste management is further addressed in the next chapter which, along with chapters six, seven and eight, discusses the three key objections to an expansion of uranium mining and use of nuclear power worldwide—waste, safety and proliferation of nuclear weapons.

5

Radioactive waste

Uranium mining and nuclear energy produce operational and decommissioning radioactive wastes which are contained and managed. Although experience with radioactive waste storage and transport over half a century has clearly demonstrated that civil nuclear wastes can be managed without adverse environmental impact, the question has become political with a focus on final disposal. In fact, nuclear power is the only energy-producing industry which takes full responsibility for all its wastes and costs this into the product – a key factor in sustainability.[1]

If you take a look at all the nuclear waste ever generated in Canada's history – that is 40 or 45 years of electricity generation – all of that waste today is stored at the plant site[s] in … very small containers. If you put it all together … it would be about the size of a basketball arena and maybe 10 feet deep. So you are talking about a very, very small amount of material that has produced … 40 years of electricity. It is just an astonishing fact.[2]

Global warming would strike me as an extreme risk for humanity whereas a small amount of decaying uranium waste in the middle of a granite craton in the middle of Australia far from any life is of absolutely minimal risk.[3]

1 Uranium Information Centre, *Submission no. 12*, p. 37.
2 Mr Jerry Grandey (Cameco Corporation), *Transcript of Evidence*, 11 August 2005, p. 9.
3 Dr Timothy Sugden (Nova Energy Ltd), *Transcript of Evidence*, 23 September 2005, p. 75.

Key messages —

- **At each stage of the nuclear fuel cycle there are proven technologies to manage and dispose of the radioactive wastes safely.**
- **While some radioactive waste is produced at each stage of the nuclear fuel cycle, the volumes of high level waste (HLW) are extremely small, contained and have hitherto been safely managed. There is an international scientific consensus that disposal in geologic repositories can safely and securely store HLW for the periods of time required for the long-lived waste to decay to background levels.**
- **The generation of electricity from a typical 1 000 megawatt (MWe) nuclear power station, which would supply the needs of a city the size of Amsterdam, produces approximately 25–30 tonnes of spent fuel each year. This equates to only three cubic metres of vitrified waste if the spent fuel is reprocessed. By way of comparison, a 1 000 MWe coal-fired power station produces some 300 000 tonnes of ash alone per year.**
- **HLW is accumulating at 12 000 tonnes per year worldwide. The International Atomic Energy Agency states that this volume of spent fuel, produced by all of the world's nuclear reactors in a year, would fit into a structure the size of a soccer field and 1.5 metres high—even without any being reprocessed for re-use. This contrasts with the 25 billion tonnes of carbon waste released directly into the atmosphere each year from the use of fossil fuels.**
- **To date, there has been no practical need and no urgency for the construction of HLW repositories. This has been due to the small volumes of waste involved and the benefit of allowing interim storage for up to several decades to allow radioactivity to diminish so as to make handling the spent fuel easier.**
- **While plans for geologic repositories are now well advanced in several countries, finding sites for repositories has been problematic. This has been due in large part to a lack of public acceptance. 'Not in my backyard' arguments about the siting of repositories have been fuelled by misperceptions of the level of risk involved in radioactive waste management and the operation of repositories. However, some countries, notably Finland and Sweden, have managed this process successfully and with a high degree of public involvement and support. In Australia, industry and Government must do more to inform and reassure the public in relation to these matters.**

- **Transport of radioactive waste is undertaken safely and securely—in sharp contrast to other energy industries. Since 1971, there have been more than 20 000 shipments of spent fuel and HLW over more than 30 million kilometres. There has never been any accident in which a container with highly radioactive material has been breached or leaked. In contrast, in OECD countries over the past 30 years more than 2 000 people have been killed in accidents involving the transport of LPG.**
- **Advanced nuclear reactors and spent fuel reprocessing technologies are now being developed which will significantly reduce the quantity and toxicity of nuclear waste, potentially reducing the required isolation period to just a few hundred years and further reducing the disposal/storage space required. These technological advances could potentially obviate the need for geologic repositories altogether.**
- **Nuclear power utilities are charged levies to provide funds for the management of the industry's waste and for the eventual decommissioning of plants. In the US, the Nuclear Waste Fund now amounts to over US$28 billion, while more than US$23 billion has been set aside for decommissioning. These costs are factored into the cost of the electricity generated and the prices paid by consumers.**
- **In contrast, wastes from fossil fuel power are not contained or managed, involve enormous volumes and a range of toxic pollutants that do not decay. Moreover, the cost of the environmental externalities these energy sources create are generally not factored into the price of the electricity produced.**

Introduction

5.1 This chapter addresses the management of radioactive waste generated across the nuclear fuel cycle, from uranium mining to the decommissioning of nuclear power plants. This is the first of three key issues which critics of uranium mining and nuclear power claim are fatal for the civil nuclear power industry. The other two issues relate to safety and proliferation. The chapter commences with a discussion of the different perceptions of risk associated with these three key issues.

5.2 The Committee provides an overview of the types of radioactive waste and describes how this waste is currently being managed. In turn, the Committee considers the:

- categories of radioactive waste;
- wastes produced in each of the nuclear fuel cycle stages;

- radioactive wastes in Australia;
- regulation of radioactive waste management;
- management and disposal of high level and long-lived waste; and
- cost of radioactive waste management and plant decommissioning.

5.3 The Committee also describes the Australian radioactive waste form known as ‘synroc’ (synthetic rock), which is a sophisticated means for immobilising high level waste.

5.4 The Committee then considers arguments critical of nuclear power and uranium mining on the basis of the waste generated, namely that:

- the disposal of nuclear waste remains an unresolved issue;
- the storage and transport of radioactive waste poses unacceptable environmental and health risks;
- radioactive waste must be secured for long periods of time and therefore imposes undue burdens on future generations; and
- reprocessing of used fuel generates larger quantities of transuranic waste and involves greater proliferation risks.

The three ‘unresolved’ issues for nuclear power

5.5 It was alleged in evidence that there remain three unresolved issues associated with the nuclear fuel cycle and its industries that, in the view of some submitters, are such as to justify a winding back of uranium mining and an eventual end to the use of nuclear power worldwide. These issues relate to the:

- generation and management of *radioactive waste* across the nuclear fuel cycle, principally waste from the operation of nuclear reactors, but also waste from uranium mines;
- *safety* of the fuel cycle, particularly the operation of nuclear reactors and the risks to health from fuel cycle industries, including uranium mining; and
- risk of *proliferation* of nuclear materials and technologies, and their diversion for use in weapons programs.

5.6 Examples of the concerns expressed by some submitters about these three key issues follows:

- The Australian Conservation Foundation (ACF) argued that:

> Risk of reactor accidents and threat of nuclear terrorism, unresolved nuclear waste management and increasing concern

> over weapons proliferation are all strong reasons for Australia to end rather than expand uranium mining and exports.[4]

- The Medical Association for the Prevention of War (MAPW) (Victorian Branch) argued that:

> The proliferation, accident, terrorist attack, and inherent nuclear fuel cycle health and environmental dangers of nuclear reactors, have never been more apparent. They are unacceptable and unsustainable …
>
> Uranium mining in Australia, rather than being expanded, should be rapidly phased out as another dangerous relic of a century in which the demise of human societies and unimaginable harm to the ecosphere, of which they are a part and which supports them, was seriously courted.[5]

- The Arid Lands Environment Centre (ALEC) submitted that:

> … there is no guarantee that Australian uranium stays out of a nuclear weapon. Nuclear power is not safe to operate, nor do we have any solutions to an already growing waste crisis.[6]

5.7 For the opponents of uranium mining and nuclear power, the risks from the use of uranium and nuclear power clearly outweigh any benefits:

> We believe that this industry poses such significant risk, if used inappropriately or poorly in either civil or military, that the risks overcome any social benefit from it.[7]

5.8 Similarly, the MAPW (Victorian Branch) expressed opposition to the export of uranium and the use of nuclear power on the basis that the risks associated with use of nuclear technology are too high:

> We see nuclear technology as inherently different from any other technology that we are called upon to make decisions about and to manage, both in terms of its quantitative potential for harm—either as weapons or otherwise—and in terms of its qualitative effects, in particular the hereditary mutagenic, carcinogenic and very persistent nature of the materials involved. Some of these risks are inherent, some are manageable clearly, but it is the considered position of my association … that these risks are really inherently too high to be acceptable.

4 ACF, *Submission no. 48*, p. 4.
5 MAPW (Victorian Branch), *Submission no. 30*, p. 16.
6 ALEC, *Submission no. 75*, p. 1.
7 Mr Dave Sweeney (ACF), *Transcript of Evidence*, 19 August 2005, p. 80.

> Any activities that increase the number of and the dissemination of facilities at which nuclear materials are handled and increase the volume and dissemination of nuclear materials do increase, we believe, the risks of accident, terrorism, proliferation and waste that are the inherent problems associated with the nuclear cycle.[8]

5.9 Convinced that the risks associated with nuclear power are 'so high', the MAPW argued that 'the threshold for decision making should err very substantially on the side of safety, and precaution should be applied to a very high degree.'[9]

5.10 In contrast, Heathgate Resources, who operate the Beverley uranium mine in South Australia (SA), argued that:

> The risks associated with the nuclear fuel cycle and uranium mining, under any rational assessment, are probably lower than the risks associated with the alternatives. One of the primary determinations of the Fox inquiry back in the seventies was that the risks associated with the nuclear fuel cycle and with uranium mining were not such that they should prohibit Australia from being involved in it. That is probably still true today.
>
> Myself and all of those working in the uranium industry—I personally have been involved in it for 30 years— are proud of what we do … We often feel misunderstood but we would like a rational assessment of all the issues relating to it because we believe that, on balance, the nuclear industry would come out ahead.[10]

5.11 On the different perceptions of risk, Heathgate also observed that:

> The bottom line decision I have come to is that their [the opponents of nuclear power] understanding, their perception of risk, is different to mine. They seem to want a world where there is no risk and unfortunately that is not life. I think a rational assessment of it all indicates that you have to accept that there are risks involved in every human activity and it is a matter of determining what is an acceptable level of those risks.[11]

5.12 The AMP Capital Investors Sustainable Funds Team (AMP CISFT), who oppose the use of nuclear power, also observed that 'the acceptable risk

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8 Associate Professor Tilman Ruff (MAPW Victorian Branch), *Transcript of Evidence*, 19 August 2005, p. 24.

9 *ibid*., p. 25.

10 Mr David Brunt (Heathgate Resources Pty Ltd), *Transcript of Evidence*, 19 August 2005, p. 103.

11 *ibid*., p. 103–04.

question is a difficult one, because everyone will have their own particular view' of what is acceptable.[12]

5.13 Representatives of BHP Billiton observed that debates about uranium need to encompass these key issues that drive public perceptions about nuclear power; namely, proliferation, waste disposal and safety:

> The public perception of the words 'uranium', 'nuclear' and words like that … is driven by issues about safety … concerns about weapons proliferation; and concerns about long-term waste disposal. I do not believe it is essentially driven by the mining of uranium per se or the generation of energy by nuclear means per se. The issues in the public mind, in my view, are around those three things, and those three things probably need to be encompassed in any debate about nuclear fuel. They are not necessarily directly related to nuclear fuel because of the differences in the forms of uranium you need to move from the power cycle into the weapons cycle, for example. They are not connected, but that is what is in people's minds.[13]

5.14 Silex Systems, an Australian company developing and commercialising a uranium enrichment technology, also noted that the 'three big issues' for nuclear power are proliferation, reactor safety and waste remediation.[14]

5.15 The following four chapters examine the evidence presented to the Committee in relation to each of these three key issues. In this chapter the Committee discusses the waste generated at each stage of the nuclear fuel cycle and its management. Chapter six addresses the safety of the nuclear power industry. Chapters seven and eight examine the proliferation of technologies and materials for weapons purposes and the effectiveness of safeguards regimes.

5.16 Before discussing the management of radioactive waste, the chapter commences with an explanation of the concepts of radiation and radioactivity. These concepts are employed in the discussion of nuclear waste in the remainder of this chapter and the discussion of the safety of the nuclear fuel cycle in the next.

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12 Dr Ian Woods (AMP CISFT), *Transcript of Evidence*, 16 September 2005, p. 30.

13 Dr Roger Higgins (BHP Billiton Ltd), *Transcript of Evidence*, 2 November 2005, p. 23.

14 Dr Michael Goldsworthy (Silex Systems Ltd), *Transcript of Evidence*, 9 February 2006, p. 4.

Radiation and radioactivity

5.17 Radioactivity refers to the spontaneous decay of an unstable atomic nucleus (referred to either as a radionuclide or a particular radioisotope), giving rise to the emission of radiation. Radiation may be understood as energy travelling through space, which can be transmitted in the form of electromagnetic waves, or it can be carried by energetic sub-atomic particles. Whereas radiation refers to the energy released during radioactive decay, radioactivity refers to the rate at which the material emits radiation. All radioactivity reduces naturally over time.[15]

5.18 The process of radioactive decay is characterised by a 'half-life'. The half-life of a radioisotope is the time taken for half of its atoms to decay, leaving the residue only half as radioactive. After 10 such half-lives, about one-thousandth of the activity remains. Each radioactive element has its own fixed half-life which can vary from seconds to many millions of years. Radioisotopes with long half-lives (e.g. uranium-238, which has a half-life of 4.5 billion years) give out very low levels of radiation, albeit over a geological time scale, whereas radioisotopes with short half-lives (e.g. radon-220, which has a half-life of 56 seconds) emits very much more radiation but over a shorter period. The rate of decay of an isotope is inversely proportional to its half life—the higher the intensity of radioactivity in a given amount of material, the shorter the half lives involved.[16]

5.19 Effects on matter of radiation fall into two classes: ionising and non-ionising radiation. Ionising radiation has energy capable of causing chemical changes damaging to living tissue and includes x-rays and the radiation from the decay of both natural and artificial radioactive substances. Non-ionising radiation includes light, heat, microwaves and radio waves.[17]

5.20 There are four types of ionising radiation, each having different penetrating powers:

- Alpha particles (atomic nuclei consisting of 2 protons and 2 neutrons) are intensely ionising but can be readily stopped by a few centimetres of air, a sheet of paper, or human skin. Alpha-radioactive substances

15 Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), 'Radioactivity', *Radiation Basics*, viewed 18 August 2006, <http://www.arpansa.gov.au/basics/radioactivity.htm>.

16 World Nuclear Association (WNA), *Radioactive Wastes*, Information and Issues Brief, March 2001, viewed 20 June 2005, <http://www.world-nuclear.org/info/inf60.htm>.

17 ARPANSA, 'Ionizing and Non-ionizing Radiation', *Radiation Basics*, viewed 18 August 2006, <http://www.arpansa.gov.au/basics/ion_nonion.htm>.

are safe if kept in any containers sealed to air. Radon gas, given out by uranium ore, has decay products that are alpha-emitters.

- Beta particles are fast-moving electrons emitted by many radioactive elements. They are more penetrating than alpha particles and can penetrate into the body, but can be shielded by a thin piece of wood or plastic. Exposure produces an effect like sunburn, but which is slower to heal. Beta-radioactive substances are also safe if kept in appropriate sealed containers.
- Gamma rays are high-energy electromagnetic waves almost identical with x-rays and of shorter wavelength than ultraviolet radiation. They are very penetrating and need substantial thicknesses of heavy materials such as lead, steel or concrete to shield them. They are the main hazard to people in dealing with sealed radioactive materials. Doses can be detected by badges worn by workers in exposed situations.
- Neutrons are mostly released by nuclear fission, and apart from a little cosmic radiation, they are seldom encountered outside the core of a nuclear reactor. Fast neutrons are very penetrating as well as being strongly ionising and hence very destructive to human tissue. They can be slowed down (or 'moderated') by wood, plastic, or (more commonly) by graphite or water.[18]

5.21 All living organisms are exposed to ionising radiation on a continuous and daily basis. This type of exposure is referred to as 'background radiation', the sources of which include radioactive materials and their decay products in the natural environment such as radioactivity in rocks and soil of the Earth's crust (referred to as terrestrial), in building materials and from outer space (referred to as cosmic radiation).[19]

5.22 There are two basic measures of radiation in the International System (SI) of units—the 'activity' of the radiation and the level of 'exposure' or dose. Activity refers to how much radiation is coming out of a radioactive material and the unit of activity is the 'becquerel' (Bq), which is the number of nuclear disintegrations per second, with one Bq equal to one nucleus decaying per second. Exposure measures the effect of radiation on substances that absorb it and is expressed in several ways, to account for the different levels of harm caused by different forms of radiation and the different sensitivity of body tissues:

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18 Uranium Information Centre (UIC), *Nuclear Electricity*, UIC, Melbourne 2003, viewed 18 August 2006, <http://www.uic.com.au/neAp1.htm>.

19 ARPANSA, 'Cosmic Radiation Exposure', *Radiation and Health Information*, 25 March 2005, viewed 18 August 2006, <http://www.arpansa.gov.au/pubs/factsheets/cosmic.pdf>;

- ‘Absorbed dose’ refers to the energy deposited in a kilogram of tissue by the radiation and is measured in a unit called the ‘gray’ (Gy), where one Gy represents the deposition of one joule of energy per kilogram of tissue.
- ‘Equivalent dose’ refers to the effect of radiation exposure on human tissue and is measured by the ‘Sievert’ (Sv) (or millisievert – mSv – which is one thousandth of a sievert, or micosievert - μSv – which is one millionth of a sievert). The equivalent dose takes into account the biological effects of the different types of radiation listed above, because some types are more dangerous to tissue than others (alpha particles and neutrons cause more damage per gray than beta or gamma radiation). Consequently, a ‘radiation weighting factor’ is taken into account in determining the equivalent dose.
- ‘Effective dose’ takes into account what part of the body was exposed to radiation, because some organs are more sensitive to radiation than others. Consequently, the effective dose incorporates a ‘tissue weighting factor’, and is also measured by the Sievert.[20]

5.23 Total natural background radiation exposure worldwide averages 2.4 mSv per year, with actual exposures varying depending on geology and altitude. The sievert is also used in setting radiological protection standards, with the maximum annual dose allowed for a uranium miner currently set at 20 mSv.[21] The health effects of radiation exposure are discussed in the following chapter.

5.24 Up to 85 per cent of the annual human radiation dose is from natural sources (e.g. buildings/soil, cosmic radiation, radon gas from the Earth and present in the air, and food), with the remainder arising from human activities, of which x-rays and other medical procedures account for the largest part.[22]

Radioactive waste

5.25 The International Atomic Energy Agency (IAEA) defines radioactive waste as:

> … material that contains, or is contaminated with, radionuclides at concentrations or activities greater than clearance levels as

20 UIC, *Radiation and Nuclear Energy*, Briefing Paper No. 17, viewed 18 August 2006, <http://www.uic.com.au/nip17.htm>; ARPANSA, ‘Units for Measuring Radiation’, *Radiation Basics*, viewed 18 August 2006, <http://www.arpansa.gov.au/basics/units.htm>.

21 UIC, *Submission no. 12*, p. 46; ARPANSA, ‘Cosmic Radiation Exposure’, *loc. cit*.

22 UIC, *Radiation and Nuclear Energy, loc. cit.*

established by the regulatory body, and for which no use is foreseen.[23]

5.26 'Clearance levels' are those established by the relevant regulatory body in each country, expressed in terms of activity concentrations and/or total activities, at or below which sources of radiation can be released from nuclear regulatory control.

5.27 Radioactive wastes (or 'radwaste') comprise a variety of materials, which can be in solid, liquid or gaseous form, requiring different types of management to protect people and the environment from the effects of ionising radiation and heat. While radwaste is generated from the use of radioactive materials in industrial applications, research and medicine, the following discussion focuses on the wastes produced from the activities associated with the generation of nuclear power; that is, the civil nuclear fuel cycle, outlined in chapter two.

Types of radioactive wastes

5.28 Some radioactive waste is produced at all stages of the nuclear fuel cycle. The persistence of the radioactivity (the decay period) determines how long the waste requires management, while the concentration (radioactivity level) and heat generation determine how the waste will be handled. These considerations also inform suitable disposal methods.[24]

5.29 Three general principles are employed in the management of radioactive waste: concentrate-and-contain; dilute-and-disperse; and delay-and-decay. While the first two are also used in the management of non-radioactive waste, delay-and-decay is unique to the management of radioactive waste. This approach involves storing the waste while its radioactivity is allowed to decrease naturally through decay of the radioisotopes in it, as described in a discussion of the management of high level waste below.[25]

5.30 The general considerations for classifying radioactive wastes are: how long the waste will remain at a hazardous level; what the concentration of the radioactive material is; and whether the waste is heat generating.[26]

5.31 The IAEA categorises radioactive waste into the classes of exempt, low, intermediate (short-lived and long-lived), and high level waste, which are summarised as follows:

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23 IAEA, *The Principles of Radioactive Waste Management*, IAEA, Vienna, 1995, viewed 18 August 2006, <http://www-pub.iaea.org/MTCD/publications/PDF/Pub989e_scr.pdf>, p. 20.

24 WNA, *Radioactive Wastes, loc. cit.*

25 UIC, *Nuclear Electricity, op. cit.*, viewed 23 August 2006, <http://www.uic.com.au/ne5.htm#5.4>.

26 WNA, *Radioactive Wastes, loc. cit.*

- Exempt waste refers to waste for which activity levels are at or below clearance levels.

  The UIC explains that this waste contains radioactive materials at a level which is not considered harmful to people or the environment. It consists mainly of demolished material, such as concrete, plaster, piping and so on, produced during rehabilitation or dismantling operations on nuclear industrial sites. The waste is disposed of with domestic refuse.[27]

- Low level waste (LLW) refers to waste in which the concentration of or quantity of radionuclides is above clearance levels. LLW contains enough radioactive material to require action for the protection of people, but not so much that it requires shielding in handling, storage or transportation.

  LLW is comprised of items such as paper, rags, tools, clothing and filters which contain small amounts of mostly short-lived radioactivity. These wastes may be disposed of in shallow land burial sites. To reduce their volume, LLW are often compacted or incinerated before disposal. LLW comprises some 90 per cent of the volume but only one per cent of the radioactivity of all radioactive wastes.

- Short-lived intermediate level waste (ILW) refers to waste that requires shielding, but needs little or no provision for heat dissipation, and contains low concentrations of long-lived radionuclides. Radionuclides in short-lived waste will generally have half-lives shorter than 30 years. Short-lived waste also refers to waste which will decay to a level considered to be insignificant in a time period during which institutional control can be expected to last.

  LLW and short-lived ILW are of three kinds: process wastes from the treatment, purification and filtration systems of fluids in direct contact with the parts of the reactor that may be contaminated with radioactivity; technological wastes arising from the necessary maintenance carried out on a nuclear power plant, such as rags, tools and protective clothing; and decommissioning wastes which occur at the end of a reactor's life.[28]

  Disposal methods for treated and conditioned LLW and short-lived ILW are typically in shallow concrete-lined trenches or engineered surface facilities, with the wastes isolated for up to 300 years, thus facilitating institutional and administrative control of the disposal site.

27 UIC, *Waste Management in the Nuclear Fuel Cycle*, Briefing Paper No. 9, viewed 17 August 2006, <http://www.uic.com.au/nip09.htm>.

28 WNA, *Radioactive Wastes*, *loc. cit.*

The IAEA reports that, worldwide, some 40 near-surface disposal facilities have been operating safely during the past 35 years, and an additional 30 facilities are expected to be in operation over the coming 15 years.[29]

- Long-lived intermediate level waste refers to waste that requires shielding, but needs little provision for heat dissipation. Concentrations of long-lived radionuclides, which have a half-life of greater than 30 years, exceed limitations for short-lived waste.

  ILW typically contains resins, chemical sludges and metal fuel cladding as well as contaminated materials from reactor decommissioning, such as the dismantled internal structures of the reactor core. Smaller items and any non-solids may be solidified in concrete or bitumen for disposal. ILW makes up some seven per cent of the volume and has four per cent of the radioactivity of all radwaste.

  Long-lived ILW (e.g. from fuel reprocessing) require a high degree of isolation from the biosphere and will eventually be disposed of in geologic repositories. This waste is being kept in interim storage pending final disposal.

  Long-lived ILW will first be treated and conditioned by incorporating it into cement and then placing it in concrete containers. In some cases, the conditioned waste will be subsequently placed into additional containers made of steel. Special packages, or casks, are used for transporting long-lived ILW.

- High level waste (HLW) contains large concentrations of both short and long-lived radionuclides, and is sufficiently radioactive to require both shielding and cooling. HLW generates more than two kilowatts per cubic metre of heat.

  HLW is generated from the use of uranium fuel in a nuclear reactor. Spent (or 'used') reactor fuel contains the fission products and transuranic elements generated during reactor operations.[30] HLW can be considered as the 'ash' from 'burning' uranium. HLW accounts for over 95 per cent of the total radioactivity produced in the process of

29 ANSTO, *Submission no. 29*, p. 10.

30 When a nucleus undergoes fission, it splits into two fragments, releases neutrons and energy. The fragments are often called *fission products*, which may be stable or unstable, i.e. radioactive. Important fission product isotopes (in terms of their relative abundance and high radioactivity) are bromine, caesium, iodine, krypton, rubidium, strontium and xenon. They and their decay products form a significant component of nuclear waste.
Transuranics are very heavy elements formed artificially by neutron capture and possibly subsequent beta decay(s). These elements have a higher atomic number than uranium (92) and all are radioactive. Neptunium, plutonium, americium and curium are the best-known.

electricity generation, but only three per cent of the volume of all radwaste.[31]

Dr Helen Caldicott argued that in the process of fissioning, the fuel becomes 'one million times more radioactive than the original uranium' and:

> … two hundred new elements are made, all of which are much more dangerous and radioactive than the original uranium. That is nuclear waste. Some last for seconds and decay. Some last for millions of years.[32]

In particular, Dr Caldicott drew the Committee's attention to iodine, strontium-90, caesium-137 and plutonium.

HLW contains materials which require a high degree of isolation from the biosphere for long periods of time. There are two distinct kinds of HLW, which are described in a section on the management of HLW, below.

Wastes produced in each of the fuel cycle stages

5.32 Mining wastes are generated by traditional uranium mining as fine sandy tailings which contain virtually all the naturally occurring radioactive elements found in uranium ore. These are collected in engineered tailings dams and finally covered with a layer of clay and rock to inhibit the leakage of radon gas and ensure long-term stability. In the short term, the tailings material is often covered with water. After a few months, the tailings material contains about 75 per cent of the radioactivity of the original ore. These are not classified as radioactive wastes.[33]

5.33 ARPANSA notes that the Olympic Dam and Ranger uranium mines produce some 10 million tonnes of uranium mill tailings per year. At the Olympic Dam mine, the coarse fraction of tailings is used underground as backfill, and the fine tailings material still containing potentially valuable minerals (rare earths, etc.) is emplaced in tailings dams. At the Ranger mine, tailings were emplaced in an engineered dam on the lease until

31 UIC, *Submission no. 12*, pp. 37–38; IAEA, *Classification of Radioactive Waste: A Safety Guide*, IAEA, Vienna, 1994, viewed 18 August 2006, <http://www-pub.iaea.org/MTCD/publications/PDF/Pub950e_web.pdf>. World Nuclear Association (WNA), *Radioactive Wastes*, *loc. cit.*; Australian Nuclear Science and Technology Organisation (ANSTO), *Submission no. 29*, p. 10.

32 Dr Helen Caldicott, *Transcript of Evidence*, 16 September 2005, p. 3.

33 UIC, *Submission no. 12*, p. 37; UIC, *Waste Management in the Nuclear Fuel Cycle*, *loc. cit*. See also: UIC, *Environmental Aspects of Uranium Mining*, Briefing Paper No. 10, viewed 21 August 2006, <http://www.uic.com.au/nip10.htm>.

1996, but are now all deposited into a worked-out pit.[34] At the Beverley mine, solid wastes are disposed of in a near-surface repository, and liquid waste is concentrated in evaporation ponds and injected into the mined aquifer.[35] The Committee considers the waste and environmental impacts of uranium mining in Australia in chapter ten.

5.34 Uranium oxide concentrate (UOC) from mining is not significantly radioactive, barely more so than the granite used in buildings. It is refined then converted to uranium hexafluoride gas (UF_6). As a gas, it undergoes enrichment to increase the U-235 isotope content from 0.7 per cent to about 3.5 to 5 per cent. It is then turned into a hard ceramic oxide (UO_2) for assembly as reactor fuel elements.

5.35 The main by-product of enrichment is depleted uranium (DU), principally the U-238 isotope, which is stored either as UF_6 or uranium oxide (U_3O_8). Some 1.2 million tonnes of DU is now stored worldwide. Some DU is used in applications where its extremely high density makes it valuable, such as radiation shielding, the keels of yachts and for military projectiles. It is also used, with recycled plutonium (Pu), for making mixed oxide fuel and to dilute highly-enriched uranium (HEU) from dismantled weapons in its conversion to reactor fuel.[36]

5.36 In terms of the waste generated during reactor operations, a typical large (1 000 MWe) light water reactor (LWR) will generate 200–350 cubic metres (m^3) of LLW and ILW per year. This waste is produced as a result of operations such as the cleaning of reactor cooling systems and fuel storage ponds, the decontamination of equipment, filters and metal components that have become radioactive as a result of their use in or near the reactor. The maintenance of a typical reactor produces less than 0.5 m^3 of long-lived ILW each year.[37] In the case of spent fuel, where this is considered waste, 20 m^3 (30 tonnes) is produced per year, which corresponds to a 75 m^3 disposal volume following encapsulation. When the same volume of used fuel is reprocessed, 3 m^3 of vitrified waste (glass) is produced, which is equivalent to a 28 m^3 volume placement in a disposal canister.[38]

34 ARPANSA, *Radioactive Waste Management in Australia*, viewed 21 August 2006, <http://www.arpansa.gov.au/is_waste.htm>.

35 G Taylor et. al., *Review of Environmental Impacts of the Acid In-situ Leach Uranium Mining Process*, CSIRO, Melbourne, 2004, pp. 35–37, viewed 12 July 2005, <http://www.environment.sa.gov.au/epa/pdfs/isl_review.pdf>.

36 UIC, *Submission no. 12*, p. 38.

37 WNA, *Radioactive Wastes*, *loc. cit*.

38 UIC, *Waste Management in the Nuclear Fuel Cycle*, *loc. cit*.

5.37 ANSTO explained that the volume of waste produced by all power reactors amounts to some 200 000 m^3 of LLW and ILW, and 10 000 m^3 of HLW (including spent fuel designated as waste) each year worldwide.[39]

5.38 Some waste is also produced during the decommissioning of nuclear reactors. Most of this material, as noted above, is LLW and short-lived ILW. About 99 per cent of the radioactivity in a reactor is associated with the fuel which is removed before invoking decommissioning options. Apart from any surface contamination of plant, the remaining radioactivity comes from 'activation products' in steel components which have been exposed to neutron irradiation for long periods. Their atoms are changed into different isotopes such as iron-55, cobalt-60, nickel-63 and carbon-14. The first two are highly radioactive, emitting gamma rays, but correspondingly with short half-lives so that after 50 years from closedown their hazard is much diminished. Some caesium-137 may also be in decommissioning wastes. Some scrap material from decommissioning may be recycled, but for uses outside the industry very low clearance levels are applied, so most is buried.[40]

5.39 The IAEA has defined three options for decommissioning, after the removal of the spent fuel:

- Immediate dismantling, also referred to as 'Decon' (decontamination) in the US, allows for the facility to be removed from regulatory control relatively soon after shutdown. In this option, all components and structures that are radioactive are cleaned or dismantled, packaged and shipped to a waste disposal site, or are temporarily stored on site.
- Safe enclosure, or 'Safstor' (safe storage), postpones the final removal of controls for a longer period, usually for up to 60 years, which allows time to act as a decontaminating agent. Once the radioactivity has decayed to lower levels, the plant is then dismantled.
- Entombment entails encasing radioactive structures, systems and components in a long-lived substance, such as concrete. The encased plant would be appropriately maintained, and surveillance would continue until the radioactivity decays to a level that permits termination of the plant's license.[41]

39 ANSTO, *Submission no. 29.1*, p. 1.

40 UIC, *Submission no. 12*, p. 43.

41 US Nuclear Energy Institute (NEI), *Decommissioning of Nuclear Power Plants*, Fact sheet, May 2002, viewed 24 August 2006, <http://www.nei.org/index.asp?catnum=3&catid=278>.

Radioactive waste in Australia

5.40 In Australia, radioactive waste is generated by research, industry, medical applications, research reactor operations and radiopharmaceutical production. Currently, Australia has accumulated about 3 800 m^3 of LLW and short-lived ILW considered suitable for disposal in a near-surface repository. This waste, which is currently stored at over 100 locations around the country, is being generated at about 40 m^3 per year (less than the volume of one shipping container). In addition, Australia has accumulated 500 m^3 of long-lived ILW and the estimated future annual arisings of long-lived ILW is some 5.5 m^3. Some long-lived ILW will be generated during the decommissioning of the research reactor at Lucas Heights and the eventual decommissioning of the replacement research reactor. Australia does not currently generate any HLW.[42]

5.41 In July 2004, the Prime Minister announced that the Australian Government will construct co-located facilities on Commonwealth land for the management of LLW and ILW produced by Australian Government agencies (which are currently stored at 30 locations around Australia). This followed the collapse in 2001 of state and Federal negotiations over the site of a proposed national waste management repository.[43]

5.42 In July 2005, the Minister for Education, Science and Training announced three potential sites for the Commonwealth Radioactive Waste Management Facility. The three sites, all located in the NT, are on Commonwealth land administered by the Department of Defence. Studies are now being undertaken to assess the suitability of these sites.[44]

5.43 ANSTO informed the Committee of the benefits of a central repository to take all of Australia's LLW and ILW. The benefits were said to include ensuring that: Australia's waste management is consistent with international best practice; all waste is stored in a purpose-built facility

42 Australian Government Department of Education, Science and Training (DEST), *Amounts of Radioactive Waste in Australia*, viewed 21 August 2006, <http://www.radioactivewaste.gov.au/Radiation_radioactive_waste/Amounts_radioactive_waste_Australia.htm>.

43 Senate Employment, Workplace Relations and Education Legislation Committee, *Report into the Commonwealth Radioactive Waste Management Bill 2005 and Commonwealth Radioactive Waste Management (Related Amendment) Bill 2005*, Commonwealth of Australia, Canberra, 2005, p. 7, viewed 31 August 2006, <http://www.aph.gov.au/Senate/committee/eet_ctte/radioactive05/report/report.pdf>.

44 DEST, *Radioactive waste management*, viewed 21 August 2006, <http://www.radioactivewaste.gov.au/radioactive_waste_management/>.

that can be properly monitored; and that all waste is properly packaged and secured.[45]

5.44 ANSTO argued that at present some waste held by the states is not packaged properly and nor is it secure.[46] The waste storage in some jurisdictions could not guarantee long-term stability. However, ANSTO sought to assure the Committee that the LLW and ILW involved is not suitable for so-called 'dirty bombs', which is examined in chapter eight.

5.45 In contrast to the position of the NT Government, the Northern Land Council (NLC) argued emphatically that 'a radioactive waste facility may be safely built in some parts of the Northern Territory'.[47] The NLC argued that if the repository is to be built in the NT, Aboriginal people should be involved in selecting its location. The NLC also remarked that there is potential for Australia to develop world's best practice in the field of waste repositories:

> So, if the Territory is to have this thing plonked on it, especially if it is to occur on Aboriginal land, we at least want to sit down at the table with the Commonwealth government and the Territory government to make sure that Aboriginal people have a say in where it goes and share in the benefits in terms of employment and in terms of an agreement. In terms of world's best practice, we believe that the Northern Territory Department of Minerals and Energy could actually deal itself into a sphere of excellence in mining and in nuclear waste repositories that would set Australia apart.[48]

5.46 The Northern Territory Minerals Council (NTMC) also expressed support for the construction of a LLW and ILW repository in the NT, or elsewhere in Australia, subject to a scientific, environmental and economic appraisal.[49]

Regulation of radioactive waste management

5.47 Standards, guidelines and recommendations for the management of radioactive waste have been developed by international and regional organisations, including the IAEA (notably its Radioactive Waste Safety Standards Program—RADWASS), OECD Nuclear Energy Agency and the International Commission on Radiological Protection (ICRP). These agencies assist countries in establishing and maintaining national

45 Dr Ron Cameron (ANSTO), *Transcript of Evidence*, 23 October 2005, pp. 16–17.

46 *ibid*., p. 17.

47 Mr Norman Fry (NLC), *Transcript of Evidence*, 24 October 2005, p. 19.

48 *ibid*., p. 22.

49 Ms Kezia Purick (NTMC), *Transcript of Evidence*, 24 October 2005, pp. 34–35.

standards. National policies, legislation and regulations are all developed from these internationally agreed standards, guidelines and recommendations.[50]

5.48 The IAEA states that the objective of radioactive waste management is to:

> … deal with radioactive waste in a manner that protect human health and the environment now and in the future without imposing undue burdens on future generations.[51]

5.49 To achieve this objective, the IAEA has established nine fundamental principles of radioactive waste management, which were published in 1995 as part of its RADWASS program, as follows:

- Protection of human health

  Radioactive waste shall be managed in such a way as to secure an acceptable level of protection for human health.

- Protection of the environment

  Radioactive waste shall be managed in such a way as to provide an acceptable level of protection of the environment.

- Protection beyond national borders

  Radioactive waste shall be managed in such a way as to assure that possible effects on human health and the environment beyond national borders will be taken into account.

- Protection of future generations

  Radioactive waste shall be managed in such a way that predicted impacts on the health of future generations will not be greater than relevant levels of impact that are acceptable today.

- Burdens on future generations

  Radioactive waste shall be managed in such a way that will not impose undue burdens on future generations.

- National legal framework

  Radioactive waste shall be managed within an appropriate national legal framework including clear allocation of responsibilities and provision for independent regulatory functions.

- Control of radioactive waste generation

  Generation of radioactive waste shall be kept to the minimum practicable.

- Radioactive waste generation and management interdependencies

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50 UIC, *Waste Management in the Nuclear Fuel Cycle, loc. cit.*

51 IAEA, *The Principles of Radioactive Waste Management, op. cit.,* p. 3.

Interdependencies among all steps in radioactive waste generation and management shall be appropriately taken into account.

- Safety of facilities

  The safety of facilities for radioactive waste management shall be appropriately assured during their lifetime.[52]

5.50 Radioactive waste management itself is defined as all activities, administrative and operational, that are involved in the handling, pre-treatment, treatment, conditioning, storage and disposal of waste from a nuclear facility, including transportation.[53]

5.51 The principal international legal agreement intended to achieve a high level of safety worldwide in spent fuel and radioactive waste management is the *Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management* (the Joint Convention), which entered into force in 2001.[54]

5.52 The Joint Convention applies to spent fuel and radioactive waste resulting from civilian nuclear reactors and applications, and to spent fuel and radioactive waste from military or defence programs if and when such materials are transferred permanently to and managed within exclusively civilian programs. The Convention also applies to planned and controlled releases into the environment of liquid or gaseous radioactive materials from regulated nuclear facilities. Wastes from the mining and milling of uranium ores are also subject to the Joint Convention.[55]

5.53 The IAEA explains that the obligations of the parties with respect to the safety of spent fuel and radioactive waste management are based to a large extent on the nine fundamental principles listed above. They include, in particular, the obligation to establish and maintain a legislative and regulatory framework to govern the safety of spent fuel and radioactive waste management and the obligation to ensure that individuals, society and the environment are adequately protected against radiological and other hazards, inter alia, by appropriate siting, design and construction of facilities and by making provisions for ensuring the safety of facilities both during their operation and after their closure. The Convention also imposes obligations on parties in relation to the transboundary movement of spent fuel and radioactive waste based on the concepts contained in the

52 *ibid.*, pp. 4–9.

53 *ibid.*, p. 20.

54 See: IAEA, *Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management*, IAEA Information Circular 546, 24 December 1997, viewed 21 August 2006, <http://www.iaea.org/Publications/Documents/Infcircs/1997/infcirc546.pdf>.

55 IAEA, *Documents Related to the Joint Convention – Background*, viewed 21 August 2006, <http://www-ns.iaea.org/conventions/waste-jointconvention.htm>.

IAEA Code of Practice on the International Transboundary Movement of Radioactive Waste.[56]

5.54 Various other international agreements seek to provide for, inter alia, the physical protection of nuclear material, the safe transportation of radioactive material, protection of the environment from radioactive waste and the control of imports and exports of radioactive waste.[57]

5.55 The regulation of radioactive waste management and disposal in Australia is the responsibility of each jurisdiction. At the state and territory level, the use of radiation and radioactivity is regulated by environmental protection authorities and state health departments. State and territory provisions are principally based on several national codes of practice and standards, described below, which in turn draw upon the international guidance mentioned above.[58]

5.56 At the Federal level, the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) is responsible for regulating the management and storage of radioactive waste at the Australian Nuclear Science and Technology Organisation (ANSTO), the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Department of Defence.

5.57 Among its other functions, ARPANSA has the responsibility of promoting uniformity of radiation protection and nuclear safety policy across jurisdictions. In this way, ARPANSA plays a major part in establishing a framework for radioactive waste management across all jurisdictions.[59]

5.58 There are currently three national codes for regulating waste management:

- The *Code of Practice for the Disposal of Radioactive Wastes by the User* (1985) provides for small amounts of low level solid waste below defined limits to be disposed of by the user to an urban land-fill waste tip. The Code is currently under revision.[60]
- The *Code of practice for the near surface disposal of radioactive waste in Australia* (1992) provides the basis for the near-surface disposal of solid radioactive waste that has been classified as LLW and short-lived ILW. The code is intended to apply to disposal of contaminated plant and equipment resulting from handling or processing of naturally-occurring materials which contain radioactive contaminants in low but non-trivial amounts, and to waste arising from processing of minerals remote from

56 *ibid*.

57 UIC, *Waste Management in the Nuclear Fuel Cycle, loc. cit*.

58 ARPANSA, *Submission no. 32*, p. 4.

59 *ibid*., p. 3.

60 See: ARPANSA, *Code of Practice for the Disposal of Radioactive Wastes by the User,* 1985, viewed 21 August 2006, <http://www.arpansa.gov.au/pubs/rhs/rhs13.pdf>.

any mine site and where disposal at the mine site is inappropriate. The code also applies to disposal of waste arising from the rehabilitation, decontamination or decommissioning of sites or facilities where radioactive materials have been produced, stored, used or dispersed. The code establishes the requirements for site selection, design criteria and operational requirements for either a national near-surface disposal facility or for a purpose-built land-fill disposal trench.[61]

- The *Code of Practice and Safety Guide for Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing* (2005) provides a uniform framework for radiation protection in the mining and mineral processing industries, and for the safe management of radioactive waste arising from mining and mineral processing.[62]

5.59 A new national code is currently being developed to cover the treatment, conditioning, packaging, storage, and transport or radioactive waste in Australia.[63]

Management of high level waste

5.60 As mentioned above, a typical large nuclear reactor generates about 25–30 tonnes of spent fuel per year. Spent reactor fuel gives rise to HLW which may be of two distinct kinds:

- in countries where used fuel is not reprocessed (that is, where countries have adopted an 'open' fuel cycle), the used fuel itself in fuel rods is considered a waste and therefore classified as HLW; or
- in countries where spent fuel is reprocessed to recycle material (that is, where countries have adopted a 'closed' fuel cycle), the fission products and transuranic elements are separated from uranium and plutonium and treated as HLW (the uranium and plutonium is then re-used as fuel in reactors, as described below).

5.61 Spent fuel assemblies discharged from a reactor core are highly radioactive and produce heat. They are therefore initially placed into large water filled pools (storage ponds) which act to cool the spent fuel and shield the radiation. The spent fuel assemblies will remain in storage ponds for a number of years while the heat and radioactivity decreases considerably. The spent fuel will then be either sent for long-term storage

61 See: ARPANSA, *Code of practice for the near surface disposal of radioactive waste in Australia*, 1992, viewed 21 August 2006, <http://www.arpansa.gov.au/pubs/rhs/rhs35.pdf>.

62 See: ARPANSA, *Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing,* 2005, viewed 21 August 2006, <http://www.arpansa.gov.au/pubs/rps/rps9.pdf>.

63 ARPANSA, *Radioactive Waste Management in Australia, loc. cit.*

or reprocessed, which typically occurs some five years after reactor discharge.[64]

5.62 If the used fuel is reprocessed, as occurs with fuel from British, French, Swiss, Japanese and German reactors, HLW comprise highly-radioactive fission products and some transuranic elements with long-lived radioactivity. These are separated from the used fuel, enabling the uranium and plutonium to be recycled. The waste generates a considerable amount of heat and requires cooling. The waste, which consists mostly of concentrated liquid nitric acid, is then incorporated into borosilicate (Pyrex) glass (vitrified), encapsulated into heavy stainless steel cylinders about 1.3 metres high and stored for eventual disposal.[65]

5.63 If the used reactor fuel is not reprocessed, all the highly radioactive isotopes remain in the fuel assembly. The entire fuel assembly is accordingly treated as HLW for direct disposal. This type of HLW also generates a lot of heat and requires cooling. However, since the used fuel largely consists of uranium (with a little plutonium) it represents a potentially valuable resource, hence there is an increasing reluctance to dispose of it irretrievably.[66]

5.64 For both types of HLW there is a cooling period of 20 to 50 years between removal from the rector and disposal, with the conditioned spent fuel or conditioned HLW from reprocessing retained in interim storage. During this period the level of radioactivity and heat from the spent fuel falls rapidly, down to one thousandth of the level at discharge after 40 years. This provides a technical incentive to delay further action with HLW until the radioactivity has reduced to a small fraction of its original level.

5.65 Interim storage facilities may be at one central location, as in Sweden (at the Central Interim Storage Facility for Spent Nuclear Fuel, or CLAB, located in Oskarshamn in southern Sweden), or at reactor sites, as in the US (where spent fuel is stored at 126 sites in 39 states).[67]

5.66 After storage for about 40 years the spent fuel assemblies are ready for encapsulation or loading into casks ready for indefinite storage or permanent disposal underground.

5.67 Direct disposal has been chosen by Finland, Sweden and, until recently, the US. However, evolving concepts lean towards making the used fuel recoverable in the event future generations see it as a resource. This requires allowing for a period of management and oversight before a

64 UIC, *Nuclear Electricity, loc. cit.*

65 UIC, *Submission no. 12*, p. 39.

66 *ibid.*

67 WNA, *Radioactive Wastes, loc. cit.*

repository is closed. Increasingly, reactors are using fuel enriched to over four per cent U-235 and burning it longer, to end up with less than 0.5 per cent U-235 in the used fuel. This provides less incentive to reprocess.[68]

Reprocessing spent fuel

5.68 Fresh uranium oxide fuel contains up to five per cent U-235. When the fuel reaches the end of its useful life and is discharged from the reactor, it contains some 95 per cent U-238, three per cent fission products (the residues of the fission reactions) and transuranic isotopes, one per cent plutonium and one per cent U-235. The plutonium is formed by the neutron irradiation of U-238. In total, some 96 per cent of the spent fuel is comprised of the original uranium and contains over half of the original energy content (excluding the U-238).[69]

5.69 Spent fuel thus contains about a quarter of the original fissile U-235 and much of the plutonium that has been formed in the reactor. Reprocessing undertaken in Europe and Russia (and planned for Japan) separates the uranium and plutonium from the wastes so they can be recycled for re-use in a nuclear reactor as mixed-oxide (MOX) fuel. There are some 34 reactors currently licensed to use MOX fuel across Europe, with 75 others in the licensing process. Japan proposes to introduce MOX fuel into 20 of its reactors by 2010.[70]

5.70 The benefits of recycling are said to be conservation of uranium (it saves 30 per cent of the natural uranium otherwise required), minimising the amount of HLW, reducing reliance on new uranium supply, reducing the inventory of separated plutonium and reduction of spent fuel storage requirements.

5.71 After reprocessing, the recovered uranium is re-enriched and then handled in a normal fuel fabrication plant. The plutonium needs to be recycled through a dedicated MOX fuel fabrication plant where it is mixed with depleted uranium oxide to make fresh MOX fuel. MOX fabrication plants are typically integrated with reprocessing plants. European reactors currently use over five tonnes of plutonium a year in fresh MOX fuel, although all reactors routinely burn much of the plutonium which is continually formed in the core by neutron capture.

5.72 Major commercial reprocessing plants operate in France (La Hague), Britain (Sellafield) and Russia (Chelyabinsk), with a capacity of some 5 000 tonnes per year and cumulative civilian experience of 80 000 tonnes over 50 years. France and Britain also undertake reprocessing for utilities

68 UIC, *Submission no. 12*, p. 39.

69 WNA, *Radioactive Wastes, loc. cit.*

70 *ibid.*

in other countries, notably Japan, which has made over 140 shipments of used fuel to Europe since 1979. At present, most Japanese used fuel is reprocessed in Europe with the vitrified waste and the recovered uranium and plutonium (as MOX) being returned to Japan to be used in fresh fuel. Russia also reprocesses some used fuel from Soviet-designed reactors in other countries.[71]

5.73 The HLW from reprocessing comprises the non-reusable part of the spent fuel; that is, both the fission products and transuranic elements other than plutonium. The fission products are then vitrified. Currently, France has two commercial plants to vitrify HLW left over from reprocessing and plants also exist in Britain and Belgium. The capacity of the western European plants is 2 500 canisters (1 000 tonnes) per year. The hulls and end fittings of the fuel assemblies are compacted to reduce the total volume of the waste and are frequently incorporated into cement before being placed into containers for disposal as ILW.[72]

5.74 The small quantities of used fuel from the Australian research reactor and the replacement reactor at Lucas Heights in Sydney are likely to be reprocessed. Some used fuel from Lucas Heights has already been shipped to Europe for reprocessing, and the small amount of separated waste will be returned to Australia for disposal as ILW.[73]

Disposal of high level waste

5.75 Whether the HLW is vitrified material from reprocessing or entire spent fuel assemblies, it eventually requires final disposal. HLW are highly radioactive for long periods of time and must therefore be isolated from the biosphere while the radioactivity decreases.[74]

5.76 In contrast to storage, which the Joint Convention defines as the holding of spent fuel or waste with the intention of retrieval, disposal means the emplacement of spent fuel or waste in an appropriate facility without the intention of retrieval, although subsequent reprocessing might be possible. This indicates that disposal is the final expected step in a waste management plan. Another distinction is that storage implies continued supervision, so that safety is provided by a combination of engineered features and active controls, whereas disposal implies a move towards reliance on the immobilisation of the waste and the passive safety functions of the disposal's system of engineered and natural barriers, making active controls unnecessary. Despite this, ANSTO noted that some

71 UIC, *Submission no. 12*, p. 40.

72 UIC, *Nuclear Electricity, loc. cit.*

73 UIC, *Submission no. 12*, p. 39.

74 ANSTO, *Submission no. 29*, p. 10.

countries are now investigating the possibility of longer-term storage, up to several hundred years.[75]

5.77 The cumulative inventory of stored spent fuel worldwide amounts to about 270 000 tonnes, much of which is located at reactor sites.[76] Annual arisings of spent fuel are about 12 000 tonnes, and one quarter of this is reprocessed.[77]

5.78 All countries that have so far made a policy decision on a final step for the management of long-lived radioactive waste have selected geological disposal—the emplacement of sealed waste-bearing canisters in mined structures (geologic repositories), typically several hundred metres below the Earth's surface in rock, clay or salt.[78]

5.79 ANSTO observed that there is now broad international scientific agreement that deep geological disposal, using a system of engineered and natural barriers to isolate the radioactive waste, is the best method of disposal for HLW.[79] This consensus is outlined in a position paper, *The Long Term Storage of Radioactive Waste: Safety and Sustainability*, which was prepared by international experts and published by the IAEA in 2003.[80]

5.80 To ensure that no significant environmental releases occur over tens of thousands of years, 'multiple barrier' concepts are proposed to isolate the wastes from the biosphere. The barriers are:

- immobilisation of waste in an insoluble matrix such as borosilicate glass or ceramic;
- sealing inside a corrosion-resistant container, such as stainless steel or copper;
- location deep underground in a stable rock structure; and
- surrounding the containers with an impermeable backfill such as bentonite clay if the repository is in a wet environment.[81]

5.81 ANSTO explained that the desired geological criteria for a repository site includes that it is distant from a watertable. Also, it is useful if the geology is such that even if the waste did migrate it would move so slowly that it would take thousands of years to reach any water table or population:

75 *ibid*., pp. 11, 12.

76 *ibid*., p. 10.

77 UIC, *Submission no. 12*, p. 40.

78 Some 14 countries propose to dispose of HLW in a geologic repository, including: Belgium, Finland, France, Germany, the Netherlands, Spain, Sweden, Switzerland, the UK and the US.

79 ANSTO, *Submission no. 29*, p. 11.

80 See: IAEA, *The Long Term Storage of Radioactive Waste: Safety and Sustainability—A Position Paper of International Experts*, IAEA, Vienna, 2003, viewed 5 September 2006, <http://www-pub.iaea.org/MTCD/publications/PDF/LTS-RW_web.pdf>.

81 UIC, *Submission no. 12*, pp. 38–39.

> So the concept is that the package provides containment, that the way you seal it in the repository provides containment and that the geology provides containment as well. All of those mean there is essentially no risk …[82]

5.82 ANSTO observed that 'Australia has some of the best geology in the world' for a repository and that 'there are hundreds of sites in Australia which would be suitable for that purpose.'[83] For example, it was noted that the site originally selected for a repository in South Australia was excellent: 'it would be tens of thousands of years before radioactivity would reach any water table' and 'by that time there is almost no radioactivity left.'[84]

5.83 The US Office of Civilian Radioactive Waste Management (OCRWM) notes that Belgium, Canada, Finland, France, Germany, Sweden, Switzerland, the UK, and the US have all performed detailed studies in underground research laboratories.[85]

5.84 The IAEA notes that it has established a Network of Centres of Excellence in Training and Demonstrations of Waste Disposal Technologies to help build confidence and capacity throughout the world in geological disposal of radioactive wastes. The network links eight underground laboratories located in Canada, Belgium, Switzerland, Sweden, UK and the US.[86]

5.85 The safety of final disposal in geologic repositories has also been examined through studies of natural analogues; notably, the sites of nuclear chain reactions which occurred in nature and produced HLW. In particular, some 17 natural nuclear reactors, which existed some 2 billion years ago in (Oklo) Gabon, West Africa, and which continued for about 500 000 years before dying away, produced nuclear waste which has remained at the site where it was generated and then naturally decayed into non-radioactive elements. These natural analogues are said to provide confirmation that long-lived waste can be safely and securely geologically isolated.[87]

5.86 The UIC stated that after being buried for about one thousand years, most of the radioactivity from HLW will have decayed. The amount of

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82 Dr Ron Cameron, *op. cit.*, p. 16.

83 *ibid.*, p. 15.

84 *ibid.*, p. 16.

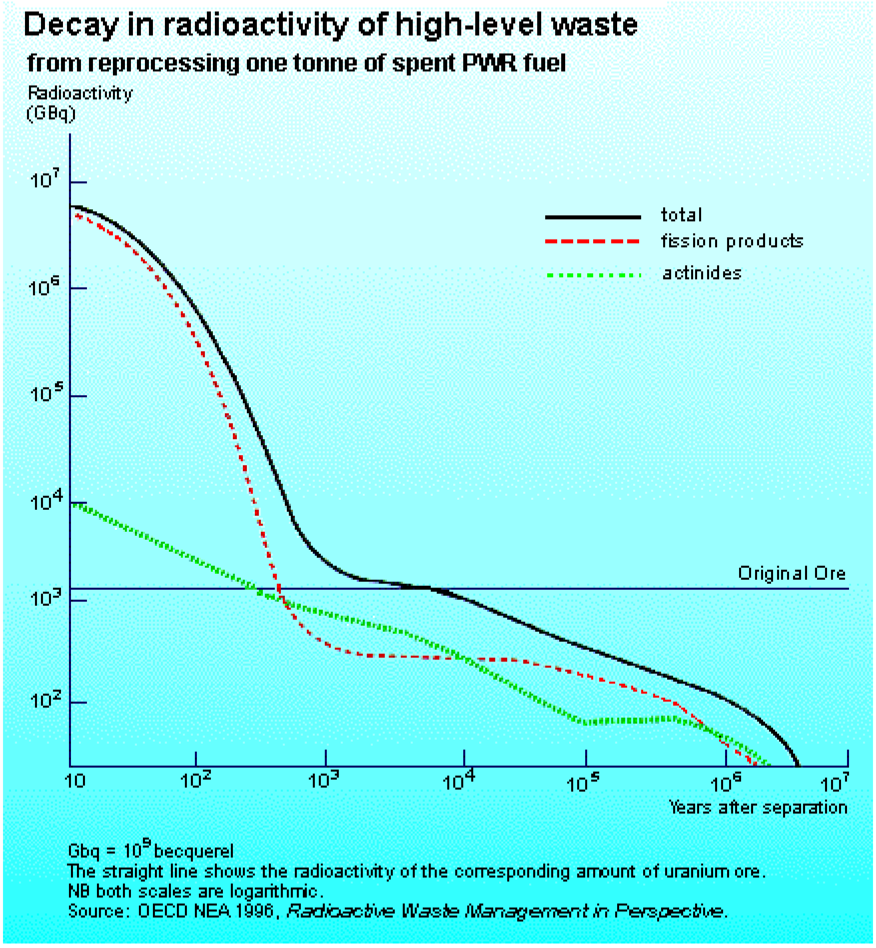
85 US Department of Energy (DOE), OCRWM, *Radioactive Waste: an international concern*, Factsheet, 2001, viewed 24 August 2006, <http://www.ocrwm.doe.gov/factsheets/doeymp0405.shtml>.

86 IAEA, *Features: Underground Repositories*, 23 January 2004, viewed 9 September 2005, <http://www.iaea.org/NewsCenter/Features/UndergroundLabs/index.html>.

87 UIC, *Submission no. 12*, p. 43.

radioactivity then remaining would be similar to that of the equivalent naturally-occurring uranium ore from which it originated, though it would be more concentrated.[88] This is illustrated in figure 5.1 which shows the decay in radioactivity of HLW from reprocessing one tonne of spent fuel.

Figure 5.1 Decay in radioactivity of high level waste



5.87 The process of selecting appropriate sites for geologic repositories for HLW is now underway in several countries with the first expected to be commissioned in the next decade. Finland and Sweden are also well advanced with plans and site selection for direct disposal of used fuel.[89]

5.88 The US has opted for a final repository at Yucca Mountain in Nevada. In July 2006 the US Department of Energy (DOE) announced that it will submit a license application to the US Nuclear Regulatory Commission (NRC) to construct the Yucca Mountain repository by mid 2008. The DOE also announced that if requested legislative changes are enacted, the

88 *ibid.*, p. 41.

89 Information on the Olkiluoto site in Finland available online, viewed 24 August 2006, <http://www.posiva.fi/englanti/>.

repository will be able to begin accepting spent fuel and HLW in 2017.[90] A geological repository, the Waste Isolation Pilot Plant (WIPP), for US military transuranic wastes has been in operation in New Mexico since 1999.

5.89 Appendix G indicates the measures that various countries have in place or planned to store, reprocess and dispose of used fuel and other radioactive wastes.

5.90 While each country is responsible for disposing of its own wastes, the possibility of international nuclear waste repositories is now being considered and Russia has enacted legislation to enable this to occur.[91] Mr Jerry Grandey also predicted that, over time, the world will shift towards a system of assurances of fuel supply combined with a few repositories from which spent fuel could be retrieved and reused.[92]

Synroc — an Australian technology for immobilising high level waste

5.91 Other than borosilicate glass, another means of immobilising HLW is an Australian-designed waste form known as 'synroc' (synthetic rock), which is a ceramic containment material for HLW. Synroc was said to represent a more sophisticated way to immobilise such waste and may eventually come into commercial use for civil wastes.[93]

5.92 ANSTO explained that waste forms to immobilise HLW must be able to prevent groundwater causing any significant movement of radionuclides back to the biosphere and that nuclear material contained within the waste form should not be able to be removed. That is, the aqueous durability and chemical resistance of the waste form is of extreme importance. It was argued that synroc, which was first developed by Professor Ted Ringwood of the ANU in 1978, has been especially designed for the immobilisation of HLW and to meet these overriding requirements.[94]

5.93 The synthetic rock waste form is an advanced ceramic composed of titanate minerals that are formed in nature, and as such are both highly stable and groundwater resistant. Synroc incorporates the waste fission products and actinides in the crystalline lattices of the synthetic materials,

90 See: DOE, Office of Public Affairs, *DOE Announces Yucca Mountain License Application Schedule*, News Releases, 19 July 2006, viewed 24 August 2006, <http://www.ocrwm.doe.gov/info_library/newsroom/documents/ym-schedule-2006.pdf>. Information on the Yucca Mountain project available online from the US Office of Civilian Radioactive Waste Management, viewed 24 August 2006, <http://www.ocrwm.doe.gov/ym_repository/index.shtml>.

91 UIC, *Nuclear Electricity, loc. cit.*

92 Mr Jerry Grandey, *op. cit.*, p. 11.

93 UIC, *Submission no. 12*, p. 40.

94 ANSTO, *op. cit.*, p. 15.

keeping them 'locked up' for millions of years.[95] It was argued that synroc has been:

> … demonstrated in nature to contain uranium, thorium, plutonium et cetera for millions of years … It is a ceramic, resistant to leaching by water and capable of being stored safely in deep underground repositories.[96]

5.94 ANSTO has continued to develop synroc for the past 25 years, with the waste form exposed to various durability and leachability tests. Various compositions of synroc have now been developed, with Professor Ringwood's original composition now referred to as synroc-A. Synroc-C is now seen as the 'standard' synroc waste form. ANSTO has also developed other forms of ceramic and glass-ceramic compositions in response to different types of waste.

5.95 In terms of its commercial applications, ANSTO submitted that, internationally, synroc is the 'the disposal route of choice for plutonium-contaminated material.'[97] ANSTO has been designing, fabricating and testing waste forms for specific applications worldwide:

- The 'synroc-D' variation has been found to be suitable for various waste streams in Russia and discussions concerning a potential 20 tonnes/year synroc plant in Russia have been held.
- A synroc waste form for immobilisation of surplus weapons plutonium was selected by a competitive process over 70 other candidate waste forms by the US government in 1997. The DOE then called for bids to build a plutonium immobilisation plant. ANSTO set up an American company (ANSTO Inc.) and a joint venture with Cogema of France through their US subsidiaries to bid for the contract to build the plant. The venture also included US companies Burns & Roe, and Battelle. After bids were submitted, the DOE announced that it was deferring immobilisation plans. This was due to a number of factors, chiefly a change in the US Administration, and the associated change in policy with regard to weapons plutonium.
- It was announced on 15 April 2005 that British Nuclear Fuels has formally approved funding for the design and construction of a demonstration facility at Sellafield in the UK to immobilise five tonnes of plutonium-containing residues in a glass-ceramic matrix developed by ANSTO. ANSTO will also provide input into the design of the plant.

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95 *ibid*. *Actinides* are those elements with an atomic number of 89 (actinium) or above. Minor actinides are americium and curium, while the major actinides are plutonium and uranium.

96 Dr Ian Smith (ANSTO), *Transcript of Evidence*, 13 October 2005, p. 12.

97 *ibid*., p. 17.

- ANSTO has recently commenced constructing the first stage of a 'mini-synroc' plant for the long-term immobilisation of the wastes from molybdenum-99 (Mo-99) production at ANSTO's own Lucas Heights facilities. Mo-99 is extracted during a process to produce technetium-99, a widely used medical diagnostic agent.[98]

5.96 In other evidence, representatives of the Australian Nuclear Forum (ANF) remarked that while synroc is without doubt the best waste form available, it may in fact offer more than is required by industry. The synroc process was also said to be more expensive than the borosilicate glass alternative. It was also submitted that countries such as France and Britain have already made very large investments in their present waste management approaches and Australia cannot realistically expect these countries to simply abandon these plans and embrace synroc. However, it was suggested that synroc will find a place for special applications and may be more widely adopted once current vitrification plants become obsolete.[99]

Disposal of other radioactive wastes

5.97 Generally, short-lived ILW (mainly from decommissioning reactors) are disposed of through near surface burial while long-lived ILW (from fuel reprocessing) will be disposed of deeper underground. Low level wastes are also disposed of in near surface burial sites.

5.98 A small proportion of low level liquid wastes from reprocessing plants are discharged to the sea. These include radionuclides which are distinctive, notably technetium-99 (sometimes used as a tracer in environmental studies), which can be discerned many hundreds of kilometres away. However, UIC stated that such discharges are regulated and controlled, and the maximum dose any person would receive from them is a small fraction of natural background.

5.99 Dr Helen Caldicott and others expressed concern about so-called 'routine releases' from nuclear reactors of noble gases—xenon, krypton and argon—and tritium, which the nuclear industry has also allegedly 'not coped with'.[100] Dr Caldicott argued that the claim by industry that it dilutes such emissions to safe levels prior to release is fallacious.[101]

98 ANSTO, *op. cit.*, p. 16.

99 Mr James Bough and Dr Philip Moore, *Transcript of Evidence*, 16 September 2005, pp. 47–48.

100 Dr Helen Caldicott, *Transcript of Evidence*, 16 September 2005, p. 14.

101 Dr Helen Caldicott, *Exhibit no. 25, Nuclear Madness*, pp. 76–77; Mr Justin Tutty, *Submission no. 41*, p. 5; Uniting Church in Australia (Synod of Victoria and Tasmania), *Submission no. 40*, p. 12.

5.100 The UIC stated that nuclear power stations and reprocessing plants do indeed release small quantities of radioactive gases (e.g. krypton-85 and xenon-133) and trace amounts of iodine-131 to the atmosphere. However, it was argued that these have short half-lives, and the radioactivity in the emissions is diminished by delaying their release. Also, the first two are chemically inert. It was argued that the net effect is too small to warrant consideration in any life-cycle analysis.[102]

5.101 Dr Caldicott made a specific allegation that the research reactor at Lucas Heights in Sydney discharges more radioactive waste into the air and water than bigger, more powerful plants overseas. It was specifically alleged that emissions of iodine-131 exceed that of the reprocessing plant at Sellafield in the UK.[103]

5.102 ARPANSA responded that airborne discharges of iodine-131 from Lucas Heights exceed those of Sellafield because of the nature of the activities undertaken at the two facilities—radiopharmaceuticals are produced at Lucas Heights, whereas Sellafield is a reprocessing facility. Consequently, the iodine-131 present in any material sent to Sellafield for reprocessing would have decayed away before it was received by the plant.[104]

5.103 In 2003–04, airborne discharges of iodine-131 from Lucas Heights amounted to 26.5 gigabecquerel (GBq). By way of context, ARPANSA explained that a common treatment for thyroid disease is the ablation of the thyroid using iodine-131 capsules. Each iodine-131 capsule can contain as much as 6 GBq of iodine-131. Hence, the total annual release of 26.5 GBq of iodine-131 from Lucas Heights is equivalent to approximately only four iodine-131 therapy capsules used for treatment of thyroid disease.[105]

5.104 ARPANSA stated that from the public health point of view, when looking at discharge levels it is important to consider the total effective doses received by the public as a result, rather than a breakdown by nuclide. The dose for all nuclides discharged from the Lucas Heights site calculated for the nearest resident to the site was 2.6 microSieverts in 2003–04:

> This is a trivial dose comparable to what might be received on a Sydney-Melbourne flight [two microsieverts] and far below doses received from discharges from the Sellafield plant. The emission of

102 UIC, *Submission no. 12*, p. 42.

103 Dr Helen Caldicott, *Exhibit no. 25, op. cit.*, p. 53.

104 ARPANSA, *Submission no. 32.1*, p. 1.

105 *ibid.*

individual nuclides are monitored to follow trends in release related to the various activities carried out by ANSTO.[106]

Costs of radioactive waste management and decommissioning

5.105 The cost of managing and disposing of nuclear power wastes was said to represent about five per cent of the total cost of the electricity generated. Most nuclear utilities are required by governments to set aside a levy (e.g. 0.1 cents per kilowatt hour in the US and 0.3 cents/kWh in Sweden) to provide for the management and disposal of wastes. More than US$28.3 billion has been committed to the US Nuclear Waste Fund to date, and the fund is growing at some $800 million per year.[107] However, the AMP CISFT claimed that it will take US utilities 50 years to collect enough to pay for Yucca Mountain, which it argued will cost $58 billion.[108]

5.106 Total costs of decommissioning vary depending on the sequence and timing of the various stages in the decommissioning program, location of the facility, current radioactive waste burial costs, and plans for spent fuel storage. However, decommissioning also typically contributes less than five per cent to total electricity generating costs. In the US, the NRC estimates that the cost of decommissioning currently ranges between US$280 and $612 million per power plant, with the US Nuclear Energy Institute suggesting that the average cost figure is about $320 million per reactor.[109]

5.107 In the US, utilities may demonstrate financial assurance for decommissioning by one or more of the following: prepayment, where utilities deposit funds in a separate account as a trust fund before the plant begins operating; nuclear power levy, which is the main US system, where utilities place funds in a trust fund outside the utility's control, based on a percentage of the electricity rates charged to consumers; and a surety fund purchased by the utility to guarantee that decommissioning costs will be paid by another party if the utility defaults.[110]

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106 *ibid*. See also: Mr James Brough, *Transcript of Evidence*, 16 September 2005, p. 47; and ANSTO, *Managing Radioactive Wastes and Spent Reactor Fuel*, Brochures, June 2003, viewed 29 August 2006, <http://www.ansto.gov.au/info/reports/manradw/wastem1g.html>.

107 UIC, *Nuclear Power in the USA*, Briefing Paper No. 58, viewed 24 August 2006, <http://www.uic.com.au/nip58.htm>; NEI, *Costs: Operating / Building / Waste Disposal*, Nuclear Statistics, viewed 24 August 2006, <http://www.nei.org/index.asp?catnum=2&catid=351>.

108 AMP CISFT, *Exhibit no. 65, The Nuclear Fuel Cycle Position Paper*, p. 18.

109 NRC, *Financial Assurance for Decommissioning*, viewed 24 August 2006, <http://www.nrc.gov/what-we-do/regulatory/decommissioning/finan-assur.html>.

110 *ibid*.

5.108 Utilities must report to the NRC at least once every two years on the status of decommissioning funds, annually once the reactor is within five years of permanently shutting down, and annually after shut down. Utilities typically collect 0.1 to 0.2 cents/kWh to fund decommissioning and, as of 2001, US$23.7 billion had been collected.[111]

Concerns about radioactive waste and its management

5.109 Those submitters that were opposed to the use of nuclear power advanced the following arguments in relation to radioactive waste:

- the disposal of nuclear waste remains an unresolved issue;
- the storage and transport of radioactive waste poses unacceptable environmental and health risks;
- radioactive waste must be secured for long periods of time and therefore imposes undue burdens on future generations; and
- reprocessing of used fuel generates larger quantities of transuranic waste and involves greater proliferation risks.

These claims are considered in turn, along with responses from industry and other submitters.

Disposal of nuclear waste is 'unresolved'

5.110 The AMP CISFT argued that nuclear waste remains an unresolved issue for three principal reasons: no country has successfully implemented a long-term plan for waste disposal and is unlikely to do so for some years; if the use of nuclear power continues to grow, a large number of repositories will need to be built and it is a significant challenge to identify where and how these will be constructed; and, third, the growth markets for nuclear power, China and India, have no plans to develop waste management sites.[112] In summary, the AMP CISFT argued that:

> … it is a bit hard to come to the conclusion that [the nuclear power industry] are responsibly managing [waste] and can demonstrate that they will be able to responsibly manage it in the near future.[113]

5.111 Specifically, AMP CISFT argued that, although the industry has had 50 years to develop a plan for the long-term storage of its HLW, it is unlikely that a repository will commence operating before 2020 at the earliest:

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111 NEI, *Decommissioning of Nuclear Power Plants, loc. cit.*

112 AMP CISFT, *Submission no. 60*, pp. 3–5.

113 Dr Ian Woods (AMP CISFT), *Transcript of Evidence*, 16 September 2005, p. 28.

> This will mean that for over 70 years, at the very least, the nuclear power industry has and will not have addressed its major life cycle waste issues.[114]

5.112 Most submitters who expressed concerns about nuclear waste also made this argument, with the MAPW (WA Branch) asserting that: 'The waste problem, unresolved despite almost 60 years of research, is on its own enough to spurn nuclear power', and the Public Health Association of Australia asserting that: 'There is no safe method of long term storage of radioactive waste, including mining tailings, spent fuel rods or plutonium.'[115] Similarly, Ms Jo Vallentine argued that:

> It has been sixty years now, that attempts have been made to find a solution to the nuclear waste problem. One has not been found. Would it not then be prudent, with the huge masses of waste already accumulated, to desist from producing more?[116]

5.113 Other submitters also argued that because no repository has yet been built, there remains no proven solution for managing long-lived waste and, hence, nuclear waste remains an 'unsolved problem.'[117]

5.114 Some submitters also expressed 'moral outrage' because, again, there is allegedly 'no working solution to nuclear waste'.[118] Other submitters claimed that: 'Nuclear waste poisons everything it touches, mutates DNA and makes the earth unable to sustain life' and 'those who allow the development of a nuclear energy industry condemn our species to certain death.'[119]

5.115 Some submitters, including Mr Justin Tutty, Mrs Judy Forsyth and Ms Jeanie Wylie, also pointed out that some waste is radioactive for very long periods of time and asserted that waste cannot be safely disposed of in repositories:

> These wastes cannot be simply disposed of underground, out of sight and out of mind, without risking leaks back into the environment. This unsolved problem has simply been left as our deadly radioactive legacy for future generations.[120]

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114 AMP CISFT, *op. cit.*, p. 3.

115 Medical Association for the Prevention of War (MAPW) (WA Branch), *Submission no. 8*, p. 2; Public Health Association, *Submission no. 53*, p. 2.

116 Ms Jo Vallentine, *Submission no. 73*, p. 2. See also: Mr Colin Mitchell, *Submission no. 67*, p. 1.

117 See for example: Mr Justin Tutty, *Submission no. 41*, p. 6; Mr David Addison, *Submission no. 59*, p. 1; Mr W M Lewis, *Submission no. 65*, p. 1.

118 Ms Stephanie Riddel, *Submission no. 80*, p. 1.

119 Ms Kathleen Winter, *Submission no. 62*, p. 1; Ms Stephanie Riddell, *op. cit.*, p. 2.

120 Mr Justin Tutty, *loc. cit.*; Mrs Judy Forsyth, *Submission no. 74*, pp. 1, 3; Ms Jeanie Wylie, *Submission no. 63*, p. 1.

5.116 AMP CISFT argued that nuclear waste storage problems would be exacerbated if nuclear power were to expand. For example, it was argued that if there was a four-fold increase in nuclear generating capacity worldwide, the estimated quantity of HLW would be of the order of 29 000 tonnes per year, assuming conventional nuclear reactor technology is used. This would allegedly require a new disposal facility equivalent to the proposed Yucca Mountain every 2.5 years. The cumulative quantity of HLW requiring disposal by 2050 under this scenario would be 922 000 tonnes, or equivalent to 13.2 Yucca Mountain facilities.[121]

5.117 It was also argued that the future growth markets for nuclear power, notably India and China, have no plans for facilities to dispose of HLW: 'This raises significant questions about the responsible long-term management of nuclear waste that may be generated from uranium mined in Australia.'[122]

5.118 Finally, a number of submitters argued that because there are allegedly 'no adequate processes for the treatment, disposal, or containment of nuclear waste', the Australian Government should not permit uranium to be mined until there is a solution for the long-term storage of nuclear waste.[123] For example, AMP CISFT argued that:

> … as a responsible nation, it is difficult to see how Australia can encourage the further growth of an industry while the significant current waste liability remains unresolved and the expansion of the industry would create even greater challenges to be resolved.[124]

5.119 Similarly, the Arid Lands Environment Centre asserted that:

> As long as there is no acceptable method for disposing of uranium, no responsible government should permit its further development.[125]

5.120 Responses to these arguments from submitters who were supportive of nuclear power and uranium mining, included that:

- there is an international scientific consensus in support of geological disposal for long-lived waste and planning is now well advanced for HLW repositories in several countries;
- there has, in any case, been no pressing need for HLW repositories to date, because spent fuel requires interim storage for up to 50 years and

121 AMP CISFT, *op. cit.*, p. 4.
122 *ibid.*, p. 5.
123 Alice Action Committee and others, *Submission no. 79*, p. 1.
124 AMP CISFT, *loc. cit.*
125 Arid Lands Environment Centre, *Submission no. 75*, p. 3.

the accumulated inventory of HLW is very small, particularly in comparison to the wastes generated by other major energy industries;

- disposal of long-lived waste is not a technical problem but a political problem—one beset by misperceptions of risk leading to 'not in my backyard' arguments around the siting of repositories;
- moves to adopt a closed fuel cycle in the US and the development of advanced fuel cycles and reactor technologies will significantly reduce the isolation period and quantity of waste requiring final disposal; and
- LLW and short-lived ILW is already being successfully disposed of, including in repositories.

5.121 ANSTO, Areva and others argued that for long-lived ILW and HLW 'there is wide international agreement on engineered geologic disposal as an effective, feasible and promising waste management end-point.'[126] Areva noted that geological disposal has the support of scientists and experts under the aegis of the IAEA, OECD and European Commission, among other organisations.[127] The US OCRWM has also stated that an international scientific consensus has emerged:

> … that deep geologic disposal is technically feasible, provides a waste disposal solution that keeps the public safe, provides for security from intrusion, prevents the diversion of nuclear materials for harmful purposes, and protects the environment for both the short and long term.[128]

5.122 Most recently, in July 2006 the UK Committee on Radioactive Waste Management (CoRWM), which had been examining the long-term management of higher level radioactive waste in the UK since 2003, published its final report. CoRWM recommended, inter alia, geological disposal as the end point for the long-term management of radioactive wastes and robust storage for an interim period of up to 100 years. CoRWM also recommended that community involvement in proposals for the siting of a repository should be based on the principle of volunteerism.[129] As noted above, all countries that have so far made a policy decision on a final step for the management of long-lived radioactive waste have selected geological disposal as the best option.

5.123 Although numerous repositories for LLW and short-lived ILW exist, there is currently only one permanent disposal facility for long-lived ILW in

126 ANSTO, *Exhibit no. 74, Presentation by Dr Ron Cameron and Dr Ian Smith*, slide 55.

127 Areva, *Submission no. 39*, p. 7.

128 OCRWM, *Radioactive Waste: an international concern*, *loc. cit*.

129 CoRWM, *Managing our Radioactive Waste Safely: CoRWM's Recommendations to Government*, CoRWM, London, July 2006, pp. 111–115, viewed 24 August 2006, <http://www.corwm.org.uk/pdf/FullReport.pdf>.

operation—the WIPP in New Mexico, for US military wastes. However, repository site selection, design and construction plans are well advanced in several countries, including Finland, Sweden and the US. For example, Finland's geological disposal site for spent fuel (Olkiluoto) was selected in 2000 and ratified by Parliament in 2001. Construction of an underground rock characterisation facility began in 2004, in anticipation of the issue of a construction license in 2010 and readiness for operation in 2020. As noted above, subject to approvals, Yucca Mountain will be able to receive waste in early 2017. BHP Billiton noted that:

> There has been a lot of work on long-term disposal of waste from power stations, particularly in the US and in Sweden in terms of disposal in geologically stable formations at depth. There has been a lot of work on that. Sweden has got a big laboratory and some of our people have visited it. It is something we are trying to learn about.[130]

Appendix G describes progress towards final repositories in various other countries.

5.124 BHP Billiton claimed that because the nuclear power industry generates small volumes of waste, there is, in any case, little need for an immediate method of long-term disposal:

> This is not an industry that generates large quantities of waste and therefore local storage is pretty easy to do. You can build storages and they are a small part of the cost of building a power station and so the pressure has not been there at this stage to go beyond that, because there is time to work out an appropriate solution for long-term disposal. Storages for the wastes being stored now do not take up a big space. They are not very difficult to construct and they are secure as they are.[131]

5.125 The UIC concurred with this view, arguing that, to date, there has been no practical need for HLW repositories as surface storage is required for up to 50 years, so that the heat and radioactivity of the waste can dissipate to levels which make handling and storage easier.[132] Similarly, the Association of Mining and Exploration Companies (AMEC) submitted that while safe methods for the final disposal of HLW are technically proven, they are not yet required.[133]

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130 Dr Roger Higgins (BHP Billiton Ltd), *Transcript of Evidence*, 2 November 2005, p. 24.

131 *ibid*.

132 UIC, *Submission no. 12*, p. 39.

133 AMEC, *Submission no. 20*, p. 5.

5.126 Moreover, the volumes of long-lived waste are said to be very small. Emphasising the very small proportion of spent fuel requiring isolation for long periods of time, ANSTO argued that:

> Ninety-five per cent of spent fuel is uranium, which is not a problem to store or worry about. You can actually reuse it. Four per cent is radioactive fission products—generally caesium and strontium are the major ones there—and they require treatment in isolation for about 200 years before they are back to background levels. One per cent of the components of the spent fuel are the materials that require hundreds of thousands of years of storage.[134]

5.127 On the long-lived wastes generated in Australia, ANSTO noted that the entire spent fuel from 40 years of reactor operations at Lucas Heights 'would come back in two large cylinders about three metres high … about 0.6 cubic metres per year.'[135]

5.128 The IAEA notes that the 12 000 tonnes of spent fuel produced from all the world's reactors each year would fit into a structure the size of a soccer field and 1.5 metres high—even without any being reprocessed for re-use.[136] Thus, the UIC argued that final disposal of HLW is not urgent in any logistical sense.

5.129 Mr Jerry Grandey argued that, rather than being the nuclear power industry's 'Achilles heel', nuclear waste is 'really the industry's strongest asset'.[137] The reasons given for this claim were that used nuclear fuel is:

> … easily contained, measured and controlled. If you take a look at all the nuclear waste ever generated in Canada's history—that is 40 or 45 years of electricity generation—all of that waste today is stored at the plant site[s] in … very small containers. If you put it all together … it would be about the size of a basketball arena and maybe 10 feet deep. So you are talking about a very, very small amount of material that has produced 35 to 40 years of electricity. It is just an astonishing fact …[138]

5.130 Areva also argued that a key feature of nuclear power is that the small quantities of waste permit sophisticated conditioning and management.[139] Likewise, Paladin Resources argued that while spent fuel is highly radioactive, the waste has several features which lends itself to ease of management: small volume; contained in the fuel assembly; decays at a

134 Dr Ian Smith, *op. cit.*, p. 12.
135 Dr Ron Cameron, *op. cit.*, p. 21.
136 Cited in ANSTO, *op. cit.*, p. 11.
137 Mr Jerry Grandey, *op. cit.*, p. 9.
138 *ibid.*
139 Areva, *Submission no. 39*, p. 7.

predictable rate; and is amenable to separation, encapsulation and isolation for the period necessary to render it harmless to the environment and people.[140]

5.131 ANSTO and industry consistently emphasised that management of radioactive waste is a political problem and *not* a technical problem. It was argued that LLW and short-lived ILW are safely stored in purpose built repositories which are in use worldwide. These wastes require compaction and, in some cases, storage in concrete. Long-lived ILW and HLW are encapsulated, usually in glass or synroc, and these are packed in highly secure casks. The encapsulation and casks are designed to last hundreds of thousands of years with low leachability.[141]

5.132 Mr John Reynolds also submitted that the problems of waste disposal are now less technical than political. The technologies are said to be well understood and a variety of safe means of disposal have been defined. Terminal storage facilities are already available in some places and in others, are being prepared.[142]

5.133 Silex explained that, as described above, there are essentially two nuclear waste forms that have been developed to date and that waste management is not a technical issue; rather, it is an issue of perception, which points to the need for improved education:

> There are two methods … borosilicate glass, which is the method that overseas countries are looking at, and a brilliant Australian invention called synroc … Currently, borosilicate glass is being used in several countries and is going to be used in the US in the future. These technologies involve the permanent immobilisation of the high-level waste inside a solid matrix. The borosilicate glass or the synroc is melted and becomes a slurry. The waste is powdered and mixed all the way through, like salt in a cake mix. This material is then cooled under high pressure. It becomes extremely hard and impervious to water. These bricks of waste matrix are then encased for safe measure. The plan is to place them in deep geological burial grounds.
>
> Successful demonstrations have already been concluded in Sweden. They have a fully operational pilot waste disposal system. There is a very large development in Yucca Mountain in the United States … I believe that the nuclear waste issue is … not a technical issue; it is [a] political and public issue—the 'not in my

140 Paladin Resources Ltd, *Submission no. 47*, p. 6.

141 ANSTO, *Exhibit no. 74, Presentation by Dr Ron Cameron and Dr Ian Smith,* slide no. 54.

142 Mr John Reynolds, *Submission no. 5*, p. 6.

> backyard' syndrome. Again, the industry needs to educate the public and governments alike.[143]

5.134 ANSTO also argued that nuclear waste management is not a technical issue but remains a problem of public perceptions:

> The technology exists. It is safe. There are international guidelines. Everything is in place. The problem is political, and that is evidenced by there being a lot of social scientists in Europe now being employed by people in this business to try and provide the community with the assurance that it needs that the technology will work … The reason that I say that it is not a technological problem is that the Champagne district in France is the host of a low-level and short-lived intermediate waste dump and it has not affected its sales, tourism or any of those things.[144]

5.135 ANSTO also pointed to waste management approaches in Finland as:

> … an excellent example of how to manage it and to get a politically acceptable solution which is accepted by the people ... they have had interim storage of spent fuel. They have built their final repositories for low and short-lived intermediate waste and they have got a final geological repository which they are building simultaneously with the new reactor program.[145]

5.136 Similarly, Mr Keith Alder, previously the General Manager and then a Commissioner of the Australian Atomic Energy Commission, argued that:

> … a tremendous amount of rubbish is talked and published about the disposal of radioactive waste. The technical and economic problems of this were solved many years ago. The remaining problems are in public relations—the NIMBY syndrome, or 'not in my backyard'; that has been amply illustrated in Australia in the near past in looking for a national repository for radioactive waste—and, of course, politics.[146]

5.137 Mr Alder stated his conviction that the final disposal solution for radioactive waste is geologic repositories:

> I firmly believe the solution is to put it back where you got it from—which is deep in the ground. That has been done in France and Sweden, and they are well advanced towards doing it in the

143 Dr Michael Goldsworthy (Silex Systems Ltd), *Transcript of Evidence*, 9 February 2006, p. 4.

144 Dr Ian Smith, *op. cit.*, p. 12.

145 *ibid.*, p. 13.

146 Mr Keith Alder, *Transcript of Evidence*, 16 September 2005, p. 80.

> United States. Australia [also] has very many suitable locations to do this.[147]

5.138 Nova Energy likewise argued that the disposal of nuclear waste is a political challenge rather than a technical issue and that the political process cannot respond to the 'not in my backyard' argument:

> … the technology to safely dispose of uranium waste is well developed. Countries like Sweden are certainly demonstrating that fact. When groups say that there is no solution and that it is an intractable problem, I think what they are really pointing at is that, whenever you suggest that there is a suitable site for disposing of uranium waste, someone will always be there saying, 'Not in my backyard.' That is the problem, not the technical issue. So I do not accept that there is no technical solution to uranium waste. I think it is just a human issue.[148]

5.139 In its position statement on the *Safe Management of Nuclear Waste and Used Nuclear Fuel*, the World Nuclear Association (WNA) argues that:

> In some countries with nuclear power, decisions on the disposal of conditioned [HLW] in deep geological repositories have been repeatedly postponed due to an absence of political will. Common misperceptions about nuclear waste have combined with political timidity to produce an impasse. Overcoming this impasse and achieving broader public support is today the central challenge for the safe long-term management of [HLW].[149]

5.140 The WNA contends that where public debate about disposal is still unresolved, the key challenges lie in two related areas: technical demonstration of the feasibility of repositories, for example, at research laboratories at underground sites; and in obtaining broader public support. The WNA argues that recent progress in Finland, Sweden, France and the US shows that these two issues are solvable:

> This experience shows that clear, transparent, step-by-step decision making—featuring public communication and involvement—can build local and national confidence to support site-selection and implementation of deep geological repositories.[150]

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147 *ibid*.

148 Dr Timothy Sugden (Nova Energy Ltd), *Transcript of Evidence*, 23 September 2005, p. 74.

149 WNA, *Safe Management of Nuclear Waste and Used Nuclear Fuel*, Position Statement, March 2005, p. 12, viewed 29 August 2006, <http://www.world-nuclear.org/position/waste.pdf>.

150 *ibid*.

5.141 However, Mr Jerry Grandey, Chief Executive Officer of Cameco Corporation, argued that opponents of nuclear power do *not* want to accept or admit that nuclear waste can be safely disposed of in repositories:

> Having participated in the debate in the US and in Canada, I can tell you that those people that are adamantly opposed to this industry … do not want a solution to the nuclear waste issue at all. If there is found to be a solution—technically it is not a problem; it [requires] a political solution—then in their mind there is no longer any argument against the use of nuclear energy. So you will find that segment of the population adamantly against any solution whatsoever …[151]

5.142 Nova Energy contended that the 'not in my backyard' arguments are the problem, not the technology to dispose of nuclear waste: 'There is a solution, but it means that the minority groups who protest need to be educated in some way to believe that the risk is minimal.'[152] Moreover, Nova argued that the risks associated with nuclear waste 'can be managed to a point where the risk level is trivial.'[153]

5.143 The risks associated with nuclear waste disposal was also compared with the costs that may be associated with global warming:

> Global warming would strike me as an extreme risk for humanity whereas a small amount of decaying uranium waste in the middle of a granite craton in the middle of Australia far from any life is of absolutely minimal risk.[154]

5.144 Similarly, the Australian Nuclear Association (ANA) argued that while perceptions of risk may well vary, 'the cost is that the greenhouse gas problem could be more dangerous in the future … than the risks of radioactive waste if we use nuclear power.'[155] Areva also submitted that the risk of any radioactive material passing the natural and engineered barriers of a repository and then reaching or affecting any population is so low that: 'There is no common measure with the global threat of climate change induced by the emission of greenhouse gases.'[156]

5.145 Submitters emphasised that the waste produced by nuclear power must also be compared to the waste generated by other energy systems. Mr Mark Chalmers, Managing Director of Heathgate Resources, argued that:

151 Mr Jerry Grandey, *op. cit.*, p. 10.

152 Dr Timothy Sugden, *loc. cit.*

153 *ibid.*

154 *ibid.*, p. 75.

155 Dr Clarence Hardy (ANA), *Transcript of Evidence*, 16 September 2005, p. 57.

156 Areva, *loc. cit.*

> I think that the whole waste concept is poorly understood generally by people in the public. The topic of nuclear waste, in my opinion, is solved … Again, it has to be looked at in the context of other waste with other energy sources also. When you look at the small quantities that are generated from nuclear power plants relative to the quantities of waste that come out of these other sources, like coal … it stacks up very well.[157]

5.146 Heathgate emphasised that some other wastes, such as arsenic, selenium, mercury and lead, are poisonous and exist forever—they never decay, unlike radioactive wastes.[158] Similarly, the UIC observed that:

> In the OECD some 300 million tonnes of toxic wastes are produced each year, but conditioned radioactive wastes amount to only 81,000 cubic metres per year. In countries with nuclear power, radioactive wastes comprise less than 1% of total industrial toxic wastes. Most toxic industrial wastes remain hazardous indefinitely.[159]

5.147 Dr Ian Smith, Executive Director of ANSTO, demonstrated to the Committee the actual volume of HLW which would be produced from generating nuclear electricity to power an average French household for twenty years (75 000 kWh). The volume of HLW fitted easily into the palm of one hand. However, if the same amount of electricity had been generated using coal, the waste produced would have been substantial:

> If they had made 75,000 kilowatt hours of electricity from coal they would have eight tonnes of solid waste which would contain uranium, thorium and heavy metals. According to the EPA in the United States, it would be quite a toxic substance with treatment times of about 10,000 years. This [the HLW] would have produced 1.5 kilograms of CO_2 and the coal would have produced 75 tonnes of CO_2.
>
> When you look at this, you can understand why France is a country whose CO_2 per dollar GDP is half the world average.[160]

5.148 The IAEA contrasts the 12 000 tonnes of HLW produced from all reactors worldwide each year with the 25 billion tonnes of carbon waste released directly into the atmosphere every year from the use of fossil fuels.[161] While a 1 000 MWe nuclear power plant generates some 30 tonnes of used

157 Mr Mark Chalmers (Heathgate Resources Pty Ltd), *Transcript of Evidence*, 19 August 2005, p. 103.

158 Mr David Brunt (Heathgate Resources Pty Ltd), *Transcript of Evidence*, 19 August 2005, p. 104.

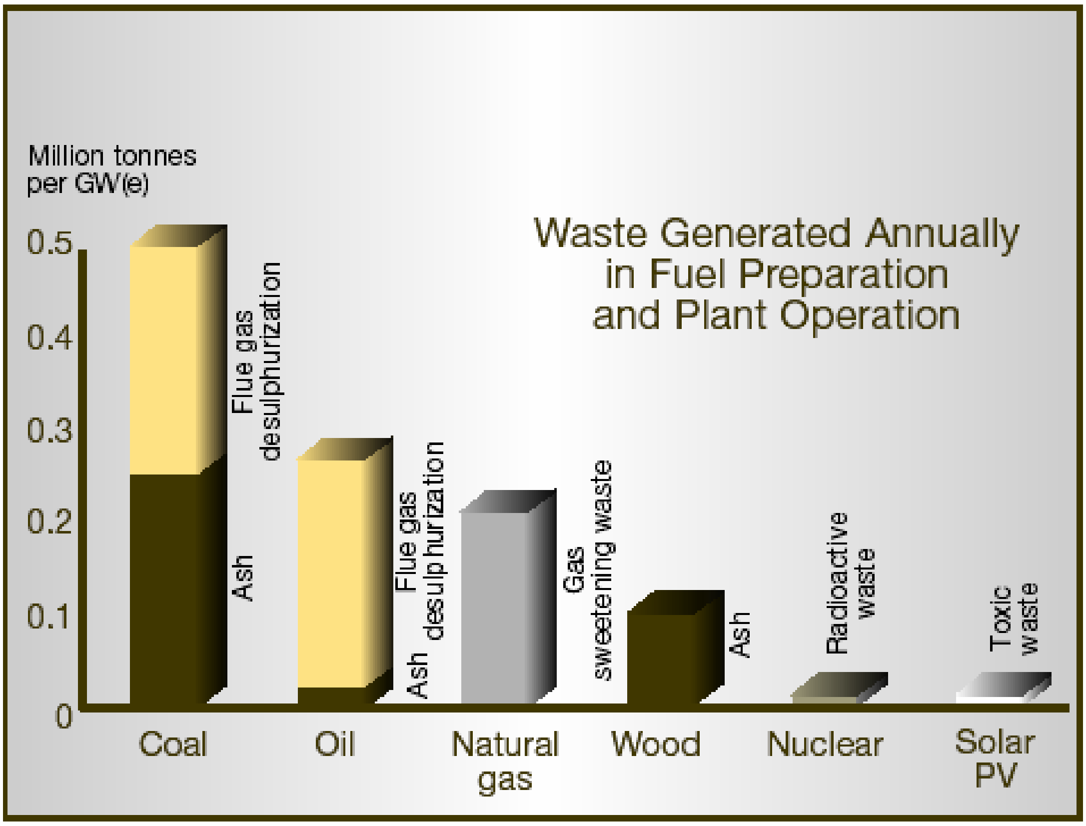
159 UIC, *Submission no. 12*, p. 37.

160 Dr Ian Smith, *op. cit.*, p. 13.

161 Cited in ANSTO, *op. cit.*, p. 11.

fuel per year, a similar sized coal plant produces some 300 000 tonnes of ash alone per year.[162] Figure 5.2 shows the volumes of waste generated annually in fuel preparation and plant operation for different energy sources. The Committee compared the environmental impacts of nuclear with coal and gas-fired power generation in the previous chapter.

Figure 5.2 Volumes of waste generated annually in fuel preparation and plant operation



Source IAEA, *Nuclear Power and Sustainable Development*, IAEA, Vienna, 2002, p. 3.

5.149 Heathgate stressed that 'it is important that the world is as educated as it can be' about the waste issue and that the wider context of waste generated by all energy sources must be properly understood.[163] On this point, Paladin Resources stressed that:

> The argument put by some that nuclear waste is 'not worth the risk' misunderstands the real risk v benefit equation which applies to all sources of energy. Nuclear power deals with waste more explicitly and transparently than many other fuels.[164]

162 See for example: Mr Alan Eggers (Summit Resources Ltd), *Transcript of Evidence*, 3 November 2005, p. 2.

163 Mr Mark Chalmers, *op. cit.*, p. 104.

164 Paladin Resources Ltd, *loc. cit.*

5.150 Similarly, Ms Pepita Maiden, a former employee of British Nuclear Fuels, remarked that nuclear power has 'the best looked after waste in the world'.[165] In comparing the waste management of the nuclear power industry with fossil fuels, Professor Leslie Kemeny also argued that:

> The hydrocarbon technology has never accepted the handling of their waste products as being a legitimate cost to their fuel cycle. I believe the nuclear industry is the only one that has looked at its waste properly.[166]

5.151 However, as noted in the previous chapter, AMP CISFT argued that the UK nuclear industry's waste management has been subsidised by the British Government 'in the order of £184 million per year, which is equivalent to £2.50 (or about A$5) per megawatt hour.'[167] It was argued that this is inconsistent with British Nuclear Fuels' claim that waste management costs £0.80 per megawatt hour. Furthermore, AMP CISFT estimated that the cost of nuclear waste disposal in the UK of some £12–13 per megawatt hour is equivalent to the cost to produce electricity in Australia.[168]

5.152 In relation to the size and number of repositories that may be required in a scenario of global growth in nuclear power, ANSTO noted that the US Government is now looking to abandon the open (or once-through) fuel cycle and reprocess used fuel to extract and re-use the uranium and plutonium, as European countries already do, 'because if they kept going like that in expanded nuclear they would have to build a Yucca Mountain every eight or nine years.'[169] Moving to a closed fuel cycle will have the effect of significantly reducing US waste volumes in the future. The Committee describes two US initiatives which could result in a dramatic increase in the capacity of the Yucca Mountain repository in the final section of the chapter.

5.153 On a related point, AMP CISFT claimed that the growth markets for nuclear power, China and India, have no plans to develop waste management sites. While the Committee did not receive any evidence on waste management plans in these countries, the OCRWM and the UIC have published information which indicates that both countries do in fact have plans for nuclear waste management.

5.154 The UIC reports that when China started to develop nuclear power, a closed fuel cycle strategy was also formulated and declared at an IAEA

165 Ms Pepita Maiden, *Submission no. 56*, p. 2.
166 Professor Leslie Kemeny, *Transcript of Evidence*, 16 September 2005, p. 93.
167 Dr Ian Woods, *op. cit.,* p. 29.
168 *ibid*.
169 Dr Ron Cameron, *op. cit.*, p. 11.

conference in 1987. The spent fuel activities involve: at-reactor storage; away-from-reactor storage; and reprocessing. The China National Nuclear Corporation has drafted a state regulation on civil spent fuel treatment as the basis for a long-term government program. The OCRWM states that China is unique in that its repository plans are being developed concurrently with the early stages of nuclear power plant construction.

5.155 The OCRWM reports that four or five repositories for low-level radioactive waste will be constructed in China to dispose of accumulated wastes from the nuclear industry, the decommissioning of nuclear facilities, and from nuclear power plant operation. These wastes will be delivered to the facilities after a five-year interim storage period. Storage ponds at Chinese reactors will hold spent fuel for 15 years which will then be reprocessed. Industrial-scale disposal of LLW and ILW wastes already occurs at two sites, in the northwest and at Bailong in Guangxi autonomous region of south China.

5.156 The UIC reports that, based on expected installed capacity of 20 GWe by 2010 and 40 GWe by 2020, the annual spent fuel arisings in China will amount to about 600 tonnes in 2010 and 1 000 tonnes in 2020, the cumulative arisings increasing to about 3 800 tonnes and 12 300 tonnes, respectively.

5.157 Construction of a centralised spent fuel storage facility at Lanzhou Nuclear Fuel Complex began in 1994. The initial stage of that project has a storage capacity of 550 tonnes and could be doubled. A pilot reprocessing plant is under construction at Lanzhou. A large commercial reprocessing plant is planned to follow.

5.158 HLW will be vitrified, encapsulated and put into a geological repository some 500 metres deep. Site selection is focused on six candidate locations and will be completed by 2020. An underground research laboratory in the Gobi Desert will then operate for 20 years and actual disposal is anticipated from 2050.[170]

5.159 In relation to waste management in India, the UIC reports that radioactive wastes from nuclear reactors and reprocessing plants are treated and stored at each site. Waste immobilisation plants are in operation at Tarapur and Trombay and another is being constructed at Kalpakkam.

170 See: OCRWM, *China's Radioactive Waste Management Program*, Fact Sheets, viewed 29 August 2006, <http://www.ocrwm.doe.gov/factsheets/doeymp0409.shtml>; UIC, *Nuclear Power in China*, Nuclear Issues Briefing Paper No. 68, viewed 29 August 2006, <http://www.uic.com.au/nip68.htm>.

Research on final disposal of HLW and long-lived wastes in a geological repository is in progress at the Bhaba Atomic Research Centre.[171]

5.160 In summary, the UIC submitted that:

> Uranium mining and nuclear energy produce operational and decommissioning radioactive wastes which are contained and managed. Although experience with radioactive waste storage and transport over half a century has clearly demonstrated that civil nuclear wastes can be managed without adverse environmental impact, the question has become political with a focus on final disposal. In fact, nuclear power is the only energy-producing industry which takes full responsibility for all its wastes and costs this into the product – a key factor in sustainability.[172]

The storage and transport of radioactive material

5.161 It was argued that there is potential for catastrophic human or technical error in the extraction, storage and transportation of radioactive material arising from the generation of nuclear power.[173] The NT Greens also argued that transport of nuclear materials poses risks of accidental environmental contamination.[174]

5.162 In contrast, the UIC submitted that HLW has been effectively and economically isolated, handled and stored safely virtually without incident in 31 countries since nuclear power began almost 50 years ago.[175] This view was endorsed by AMEC and Professor Leslie Kemeny, who also argued that HLW has been safely contained, stored and transported for over 50 years.[176]

5.163 Mr John Reynolds also submitted that:

> There is no record of adverse health effects or significant incidents or accidents in the handling, storage, transport and re-processing of used nuclear fuel … from electricity generation over the fifty year life of the industry.[177]

5.164 This evidence was corroborated by information published by the OCRWM in relation to the US experience of radioactive waste transport. Over the

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171 See: UIC, *Nuclear Power in India and Pakistan*, Nuclear Issues Briefing Paper No. 45, viewed 29 August 2006, <http://www.uic.com.au/nip45.htm>.

172 UIC, *Submission no. 12*, p. 37.

173 Alice Action Committee, *loc. cit*; Dr Helen Caldicott, *Exhibit no. 25*, *op. cit*., pp. 69–79.

174 NT Greens, *Submission no. 9*, p. 1.

175 UIC, *Submission no. 12*, p. 38.

176 AMEC, *op. cit*., p. 5; Professor Leslie Kemeny, *Submission no. 64*, p. 9.

177 Mr John Reynolds, *loc. cit.*

last 40 years approximately 3 000 shipments of spent fuel have been transported safely across some 1.7 million highway, rail and barge miles in the US. During this time, there have been no injuries, fatalities or environmental damage caused by the radioactive nature of the cargo.[178]

5.165 The OCRWM states that among several factors that have contributed to this success is the design of the casks in which the spent fuel assemblies and other HLW are transported. The casks are designed to keep the radioactive material from being released into the environment under both normal and accident situations. The casks must be able withstand a series of destructive tests: being dropped onto unyielding surfaces, punctured, exposed to intense heat, and being submerged under water. The NRC has also established regulations to minimise the possibility of theft, diversion, or attacks on waste shipments.[179]

5.166 The UIC states that since 1971 there have been more than 20 000 shipments of spent fuel and HLW (over 50 000 tonnes) over more than 30 million kilometres. It is claimed that there has never been any accident in which a container with highly radioactive material has been breached, or has leaked.[180]

5.167 Dr Ian Smith also argued that large quantities of radioactive material have been safely transported around the world for decades without incident—in sharp contrast to other fuels:

> In the OECD countries in the last 30 years more than 2,000 people have been killed in transportation accidents shifting LPG around … For the nuclear industry, 20 million packages have been sent 30 billion kilometres without an accident. This is not an area where the facts indicate that there is a problem, though I guess there is a perception of a problem.[181]

5.168 The transport of radioactive material in Australia is conducted according to the Australian *Code of Practice for the Safe Transport of Radioactive Material* (2001), which effectively adopts international transportation requirements established by the IAEA.[182] The Code has been adopted by all the states and territories with the exception of Victoria, which ARPANSA notes is

178 See: OCRWM, *Transportation of Spent Nuclear Fuel*, Fact Sheet, viewed 29 August 2006, <http://www.ocrwm.doe.gov/factsheets/doeymp0500.shtml>.

179 *ibid*. See also: OCRWM, *Transportation of Spent Nuclear Fuel and High-Level Radioactive Waste t Yucca Mountain: Frequently Asked Questions*, January 2006, viewed 29 August 2006, <http://www.ocrwm.doe.gov/transport/pdf/snf_transfaqs.pdf>.

180 UIC, *Transport of Radioactive Materials*, Nuclear Issues Briefing Paper no. 51, viewed 5 September 2006, <http://www.uic.com.au/nip51.htm>.

181 Dr Ian Smith, *op. cit*., p. 12.

182 See: ARPANSA, *Code of Practice for the Safe Transport of Radioactive Material,* 2001m, viewed 29 August 2006, <http://www.arpansa.gov.au/pubs/rps/rps2.pdf>.

now moving to adopt the Code. Among other elements, the Code establishes: provisions about a radiation protection program; emergency response; quality assurance; compliance assurance; requirements for packages (e.g. transportation casks) and definitions of package types.[183]

5.169 ANSTO notes that it transports radioactive material in accordance with the national Code and international standards. ANSTO states that the LLW and short-lived ILW which will eventually be transported to the Commonwealth Radioactive Waste Management Facility will be shipped in containers designed to remain intact in the event of an accident. Because ANSTO will only be transporting solid wastes, there is no danger of any leakage. Furthermore, ANSTO states that even in the event of an accident, because of the low levels of radiation in the waste and because of its solid nature, there would be no significant or life-threatening radiological consequences.[184]

Intergenerational equity

5.170 The NT Greens and the Uniting Church in Australia (Synod of Victoria and Tasmania) emphasised the issue of intergenerational equity: that the use of nuclear power comes at a cost for future generations who, it is claimed, must manage and secure the nuclear waste.[185] For example, the Uniting Church argued that:

> … present-day generations have no right at all to impose on future ones the enormous cost of human resources to care for the wastes and obsolete installations they leave behind them, to say nothing of the continuous risks this involves;

and

> Future generations have a right 'not to be confronted with products and wastes of earlier generations that threaten their health or require excessive expense for protection and control'.[186]

5.171 In relation to the ethical aspects of radioactive waste management, the UIC points to statements by the IAEA and OECD which support the geological disposal of long-lived wastes. For example, in 1995 the Radioactive Waste Management Committee of the OECD Nuclear Energy Agency (OECD-NEA) published a collective opinion on the ethics of radioactive waste management which considered, inter alia, that:

183 ARPANSA, *op. cit.*, pp. 5–6.

184 See: ANSTO, *Managing radioactive waste*, Brochure, May 2006, viewed 29 August 2006, <http://www.ansto.gov.au/info/brochures/Managing%20Radioactive%20Waste.pdf>.

185 NT Greens, *loc. cit.*

186 The Uniting Church in Australia (Synod of Victoria and Tasmania), *Submission no. 40*, pp. 6, 11.

- … from an ethical standpoint, including long-term safety considerations, our responsibilities to future generations are better discharged by a strategy of final disposal than by reliance on stores which require surveillance, bequeath long-term responsibilities of care, and may in due course be neglected by future societies whose structural stability should not be presumed;
- … after consideration of the options for achieving the required degree of isolation of such wastes from the biosphere, geological disposal is currently the most favoured strategy;
- **…** the strategy of geological disposal of long-lived radioactive wastes:
  - ⇒ takes intergenerational equity issues into account, notably by applying the same standards of risk in the far future as it does to the present, and by limiting the liabilities bequeathed to future generations; and
  - ⇒ takes intragenerational equity issues into account, notably by proposing implementation through an incremental process over several decades, considering the results of scientific progress; this process will allow consultation with interested parties, including the public, at all stages.[187]

5.172 The Radioactive Waste Management Committee concluded that:

- … the geological disposal strategy can be designed and implemented in a manner that is sensitive and responsive to fundamental ethical and environmental considerations;
- **…** it is justified, both environmentally and ethically, to continue development of geological repositories for those long-lived radioactive wastes which should be isolated from the biosphere for more than a few hundred years; and
- … stepwise implementation of plans for geological disposal leaves open the possibility of adaptation, in the light of scientific progress and social acceptability, over several decades, and does not exclude the possibility that other options could be developed at a later stage.[188]

5.173 Following a survey of OECD member countries, the IAEA and European Commission, the OECD-NEA's Radioactive Waste Management Committee issued an updated statement in 1999. The statement found that the consensus for pursuing geologic disposal as the only feasible route for assuring permanent isolation of long-lived wastes from the human environment remained unaffected.[189]

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187 Cited in UIC, *Waste Management in the Nuclear Fuel Cycle, loc. cit.*

188 *ibid.*

189 *ibid.*

5.174 Among other findings, the review of developments in the geological disposal of radioactive waste over the preceding decade noted that delays in developing repositories have mainly been due to insufficient public confidence. It was argued that:

> There is an acute awareness in the waste management community of this lack of public confidence; efforts are needed by both implementers and regulators to communicate effectively to decision makers and the public their consensus view that safe disposal can be achieved.[190]

5.175 ANSTO submitted that geologic repositories are being designed so that they will not require monitoring and institutional controls.[191] However, another development noted by the OECD-NEA Committee has been a shift to establish strategies and procedures that will allow long-term monitoring of repositories, with the possibility of reversibility and retrievability.

Reprocessing

5.176 AMP CISFT and Friends of the Earth–Australia (FOE) argued that reprocessing of spent nuclear fuel does not represent a solution to the disposal of HLW. The reasons given for this were the proliferation risks involved in separating plutonium during reprocessing, which could then potentially be diverted for weapons purposes, and because reprocessing generates a greater quantity of transuranic waste. However, FOE and AMP CISFT conceded that the volume of the HLW stream requiring permanent disposal is indeed reduced by reprocessing.[192] The Committee addresses the proliferation aspects of reprocessing in chapters seven and eight.

5.177 Other submitters emphasised the significant reduction in waste volumes requiring geological disposal following reprocessing and the gains in resource utilisation. The WNA argues that:

> While the burden of nuclear waste is in any case remarkably small, reprocessing used nuclear fuel offers a means to reduce still further—by over 75 per cent—the overall volume of material requiring disposal in a deep geological repository.[193]

5.178 While ANSTO conceded that reprocessing may offer an opportunity for proliferation, it 'nonetheless minimises waste and maximises the use of the

190 *ibid*.

191 ANSTO, *Submission no. 29*, p. 11.

192 FOE, *Submission no. 52*, p. 12; AMP CISFT, *op. cit.*, p. 4.

193 WNA, *Safe Management of Nuclear Waste and Used Nuclear Fuel, op. cit.*, p. 14.

uranium.'[194] Moreover, ANSTO stated that 'the … value of spent fuel is quite enormous. Twenty per cent of the fuel load of the new generation of rectors will be spent fuel from the current reactors.'[195] Similarly, Mr Jerry Grandey argued that used nuclear fuel remains a potential source of energy and should therefore be stored rather than disposed of permanently:

> Ninety per cent of the energy is left in the spent fuel after it comes out of the reactor … spent fuel will be a tremendous resource. Hence it ought to be kept in storage.[196]

5.179 As noted in the discussion of reprocessing earlier in the chapter, the benefits of recycling uranium and plutonium into fresh fuel are said to include conservation of uranium, minimising the amount of HLW, reducing the inventory of separated plutonium and reduction of spent fuel storage requirements. Reprocessing also avoids leaving the plutonium in the used fuel, where it could eventually be recovered for illicit use.

Technologies to reduce the volume and toxicity of radioactive waste

5.180 Evidence suggested that developments in fuel cycle technologies may lead to a simplification of strategies for waste disposal. In particular, advanced reactors and new fuel cycles are now being proposed that will reduce the toxicity of waste, implying that isolation periods will not need to be as long, and further reduce waste volumes thereby reducing demands on repositories. In particular, new reprocessing technologies are being developed to be deployed in combination with fast neutron reactors. These developments also offer significant non-proliferation advantages and the main programs in which these technologies are being developed are described more fully in chapter seven.

5.181 ANSTO, ASNO, UIC and the Australian Institute of Nuclear Science and Engineering (AINSE) noted that research is now being undertaken to make radioactive waste less aggressive through transmutation, which offers a means of rapidly reducing the radiotoxicity of some waste. The UIC and ASNO explained that in the last ten years interest has grown in separating ('partitioning') individual radionuclides both to reduce long-term radioactivity in residual waste and to be able to turn separated long-lived radionuclides into shorter-lived ones, mostly by fission:

194 Dr Ian Smith, *op. cit.*, p. 13.

195 *ibid*.

196 Mr Jerry Grandey, *op. cit.*, pp. 10–11.

> … transmutation refers to the process of gaining a substantial reduction in the period over which waste arising from nuclear energy remains highly radiotoxic, by using the neutron flux within a reactor or other intensive source of neutrons to turn (transmute) long-lived radiotoxic elements into short-lived or stable elements. This transmutation step can substantially decrease the time needed to render the partitioned material harmless.[197]

5.182 ANSTO explained that while spent fuel may normally take 300 000 years before its activity reduces to the level of natural radiation from uranium ore, transmutation could reduce this to 300 years, as depicted in figure 5.3.[198] The top line indicates the activity of used fuel without treatment and the bottom line indicates the activity of used fuel with transmutation in advanced fuel cycles.

5.183 However, FOE expressed reservations about transmutation on the grounds that: the technology is immature and its future uncertain; it is useful only for certain types and forms of waste; it does not do away with the need for long-term management of the resulting wastes; it may require the use of reactors; and it may require reprocessing to separate waste streams prior to selective treatment.[199]

5.184 In contrast, AINSE was highly supportive of accelerator or reactor-driven waste destruction research of this kind and urged that Australia increase its involvement in the field.[200]

5.185 ASNO explained that efficient transmutation requires fast neutrons (those not slowed down by a moderator). Research into partitioning and transmutation initially arose in the context of expectations of the early deployment of fast breeder or other fast neutron reactors (FNRs), which did not eventuate.[201]

197 ASNO, *Exhibit no. 93, Informal briefing on the US Global Nuclear Energy Partnership*, p. 13; UIC, *Processing of used nuclear fuel*, Nuclear Issues Briefing Paper No. 72, viewed 30 August 2006, <http://www.uic.com.au/nip72.htm>.

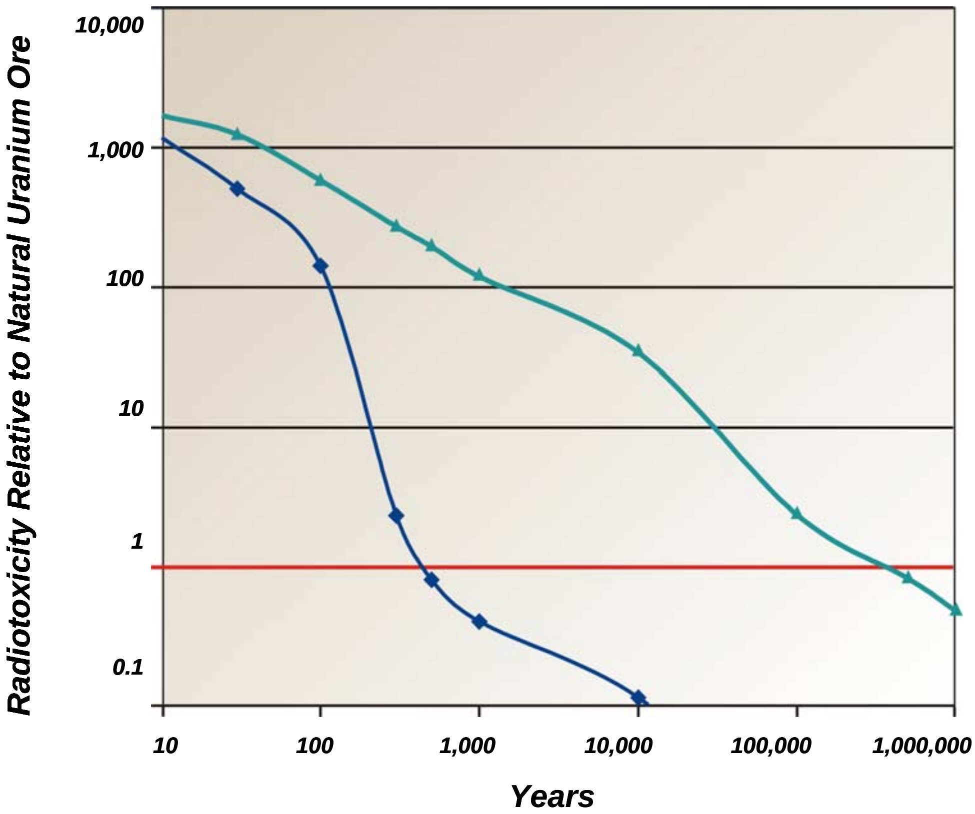
198 Dr Ian Smith, *op. cit.*, pp. 13–14.

199 FOE, *op. cit.*, p. 14.

200 AINSE, *Submission no. 77*, p. 2.

201 ASNO, *Exhibit no. 93, loc. cit.*

Figure 5.3 The effect of transmuting plutonium and higher actinides on the radiotoxicity of used nuclear fuel



Source ANSTO, *Exhibit no. 74, Presentation by Dr Ron Cameron and Dr Ian Smith,* slide 58.

5.186 However, as described more fully in chapter seven, in February 2006 the US Government announced a Global Nuclear Energy Partnership (GNEP) initiative which seeks to deploy FNRs for this purpose. Among its other objectives, GNEP intends that long-lived waste material will undergo treatment so that it can be transmuted into much shorter-lived materials. The GNEP proposal contains two significant elements:

- new reprocessing technology ('advanced spent fuel separation') in which plutonium is not fully separated, but remains mixed with uranium and highly radioactive materials (i.e. all transuranic elements are separated together, and not plutonium on its own); and
- deployment of Advanced Burner Reactors (ABRs), which are a type of FNR, to consume fuel which will be fabricated from the mix of uranium/plutonium plus most of the actinides and fission products.[202]

5.187 In ABRs, the fast neutrons are effective in fissioning the actinides and fission products so that they are transformed into shorter-lived materials. Hence, the eventual waste will have a shorter life.

202 *ibid.*, p. 2.

5.188 ASNO explained that as a result of these processes, GNEP promises to reduce the quantity of HLW and reduce the period HLW must be isolated from the environment—from around 10 000 years, which is the standard time period cited by industry, down to between 300 and 500 years. Furthermore, the resulting shorter-lived HLW may not necessarily need deep geologic disposal and could potentially be stored in specially designed above-ground buildings. This means that most countries with nuclear power would then be in a position to handle their own HLW (not just those with suitable geology for repositories).[203]

5.189 In other developments, ANSTO informed the Committee that two other initiatives, the Generation IV International Forum (GIF) and the US Advanced Fuel Cycle Initiative (AFCI) are also developing technologies which will have implications for waste management. Again, these initiatives are also intended to address proliferation hazards and are described at greater length in chapter seven.

5.190 A priority for both the GIF and AFCI is integrated waste management which:

> … implies the minimisation and management of radioactive waste, including reduction of the long-term stewardship burden, through for example the design and development of fuel that is directly disposable after use.[204]

5.191 AFCI aims to develop a fuel cycle which, in addition to assisting the transition from a once-through fuel cycle to the recycling of nuclear materials, will also reduce the toxicity and volume of waste. It is intended that these technologies will be deployed to support current nuclear power plants and, eventually, Generation IV reactor systems. The DOE explains that:

> In the longer term, AFCI's development of a system involving spent-fuel partitioning and recycling of actinides and other long-lived radioactive components in fast reactors for destruction through transmutation could result in a de facto fifty-fold increase in the technical capacity of the planned Yucca Mountain repository. This increase would come principally from the destruction of highly-radioactive materials contained in spent fuel (actinides) that generate the heat that limits repository capacity. Such a capacity increase would be more than enough to

203 *ibid*.

204 ANSTO, *op. cit.*, p.19.

> accommodate all the spent fuel generated in the US this century from any conceivable nuclear energy deployment scenario.[205]

5.192 GIF has identified six reactor technologies which the Forum members believe represent the future of nuclear energy. Some of these reactor types, such as the Modular Helium Reactor (MHR), now in advanced development by General Atomics (GA), allows for a so-called 'deep burn' (i.e. very extensive destruction) of transuranic waste. This means that the reactor is able to consume long-lived actinides from the spent fuel of conventional reactors and turn this into short-lived fission products. It is claimed that 95 per cent of the plutonium-239 and 60 per cent of the other actinides would be destroyed. The deep burn transmutation of transuranic waste promised by the MHR technology is expected to: significantly reduce the volume of residual waste requiring disposal in repositories; eliminate the attractiveness of the remaining waste for weapons purposes; and significantly reduce the amount of secondary waste production by minimising the reprocessing steps required.[206]

Conclusions

5.193 The Committee concludes that the radioactive wastes which are produced at each stage of the nuclear fuel cycle have, since the inception of the civil nuclear power industry 50 years ago, been responsibly managed. There are proven technologies for the management of all types of radioactive waste. For example, worldwide, some 40 near-surface disposal facilities for LLW and short-lived ILW have been operating safely for the past 35 years.

5.194 The Committee concurs with submitters that nuclear power deals with its waste more explicitly and transparently than many other sources of energy. Indeed, as one submitter observed, nuclear power has 'the best looked after waste in the world.'[207]

5.195 The Committee notes that HLW has several features which lends itself to ease of management: very small volumes; the radioactivity is contained in the spent fuel assemblies; it decays at a predictable rate; and is amenable

205 DOE, *Advanced Fuel Cycle Initiative*, January 2006, viewed 30 August 2006, <http://nuclear.gov/infosheets/afci.pdf>.

206 GA, *Exhibit no. 80*, *Sustainable Long Term Nuclear Power: Destruction of Nuclear Waste and Recycle of Resources for the long run using MHR Deep Burn Technology and Fusion*, slide 25. See also: Dr Ian Smith, *op. cit.*, p.13; UIC, *Nuclear Power in USA*, *loc. cit*; C Rodriguez et. al., 'Deep-Burn: making nuclear waste transmutation practical', *Nuclear Engineering and Design* 2805 (2003), p. 18.

207 Ms Pepita Maiden, *loc. cit*.

to separation, encapsulation and isolation. Moreover, the nuclear power industry significantly contributes to the cost of its waste management through levies imposed on utilities. That is, the cost of managing radioactive waste is internalised in the price of the electricity generated.

5.196 This is in sharp contrast to the wastes produced by fossil fuels, which are not contained or managed, involve enormous volumes and a range of toxic pollutants that do not decay. Moreover, the cost of the environmental externalities these energy sources create are generally not factored into the price of the electricity generated.

5.197 Much of the focus of submitters' concerns related to the management of long-lived waste. The Committee concludes that spent nuclear fuel has been routinely and safely removed from reactors, handled, stored, transported and reprocessed since the industry's inception.

5.198 To date, there has been little practical requirement for a means of final disposal of long-lived waste for two main reasons: the volumes of long-lived waste are very small; and spent fuel can be usefully placed in interim storage for up to several decades, to allow heat and radioactivity to dissipate, which assists handling.

5.199 The Committee wishes to emphasise the very small quantities of HLW that are generated worldwide each year—12 000 tonnes. The IAEA states that this volume of waste would fit into a structure the size of a soccer field and 1.5 metres high. The volume is significantly reduced—by over 75 per cent—if the spent fuel is reprocessed. The accumulated inventory of stored spent fuel amounts to only 270 000 tonnes.

5.200 The Committee believes that those opposed to the use of nuclear power are wrong in their assertion that there remains 'no solution' to dealing with spent fuel. There is an international consensus in support of geologic repositories for disposal of long-lived waste and plans for repositories are now well advanced in several countries.

5.201 However, the Committee notes that gaining public acceptance of radioactive waste management methods and, in particular, support for the siting of waste repositories has at times been difficult. This points to the importance of properly informing and reassuring the public about the real risks associated with radioactive waste, the management approaches used for the various types of waste, and the merits of geological disposal for long-lived waste.

5.202 The Committee notes the observation by the Director General of the IAEA that although most of the technical issues for spent fuel disposal or reprocessing have been solved and nuclear power produces only 12 000 tonnes of spent fuel per year, nevertheless:

> … public opinion will likely remain skeptical—and nuclear waste disposal will likely remain controversial—until the first geological repositories are operational and the disposal technologies fully demonstrated.[208]

5.203 The Committee hopes that, as the Director General of the IAEA remarks, community acceptance of HLW disposal will grow as repositories in Finland, the US, Sweden and elsewhere begin to operate. In Australia, it is to be hoped that the successful opening of the Commonwealth waste management facility will have a similar effect. The Committee returns to the issue of public acceptance and perceptions of risk in a discussion of the impediments to the industry's development in chapter 11.

5.204 The Committee suspects that it is in the interests of those adamantly opposed to nuclear power to continue to oppose construction of repositories and to exacerbate the 'not in my backyard' syndrome, precisely in order to perpetuate claims that 'no solution' exists for disposing of HLW and spent fuel. The Committee believes that this is not a constructive position to take.

5.205 The Director General of the IAEA has also advocated the possibility of multinational approaches to spent fuel management and disposal, noting that:

> Not all countries have the right geology to store waste underground and, for many countries with small nuclear programs, the costs of such a facility would be prohibitive.[209]

5.206 The Committee repeats the observation by ANSTO that 'Australia has some of the best geology in the world' for a repository and that 'there are hundreds of sites in Australia which would be suitable for that purpose.'[210] The Committee notes the constructive position taken by the NLC, which has supported the possible location of a radioactive waste facility in the NT, subject to the approval of the Traditional Owners. The Committee returns to this issue in chapter 12.

5.207 The Committee was also informed that there have been no adverse health effects or significant accidents associated with the transport of spent nuclear fuel. However, the same cannot be said for other energy industries, with evidence revealing that more than 2 000 people have been killed in LPG transportation accidents in OECD countries over the past 30 years.

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208 Dr Mohamed ElBaradei, *Nuclear Power: Preparing for the Future*, 21 March 2005, viewed 28 August 2006, <http://www.iaea.org/NewsCenter/Statements/2005/ebsp2005n004.html>.

209 *ibid*.

210 Dr Ron Cameron, *op. cit.*, p. 16.

5.208 This leads to another issue raised by industry—that the waste generated by nuclear power must be compared to the waste generated by other energy sources. In this respect, the Committee notes the evidence that 300 million tonnes of toxic waste is produced annually in the OECD, but conditioned radioactive waste amounts to only 81 000 cubic metres. In countries with nuclear power, radioactive wastes comprise *less than one per cent* of total industrial toxic wastes, much of which never decays—unlike radioactive wastes—and remains hazardous forever. Furthermore, while the world's nuclear power plants generate 12 000 tonnes of HLW each year, some 25 billion tonnes of carbon waste is released directly into the atmosphere every year from the use of fossil fuels.

5.209 Moreover, industry argued that we should not fail to appreciate the risk versus benefit equation which applies to all energy systems. In this regard, the Committee concurs with those submitters who compared the trivial risks associated with geologic disposal of long-lived radioactive waste to the extreme risks for humanity from the uncontrolled emissions of carbon dioxide leading to global warming.

5.210 Claims that the generation of radioactive waste, its management and transportation pose unacceptable risks simply do not reflect the realities. Some submitters misperceive the risks involved and either misunderstand or ignore the historical record. The facts indicate that the radioactive wastes generated at the various stages of the nuclear fuel cycle continue to be safely and effectively managed. Indeed, the way in which the nuclear power industry manages its waste is an example for other energy industries to follow.

5.211 In the following chapter, the Committee considers the safety and public health implications of nuclear power and other fuel cycle activities.

6

The safety of the nuclear fuel cycle

> *Despite popular misconceptions, nuclear power has an unmatched safety record relative to all base load fuels. It is far safer per megawatt hour generated than hydrocarbon fuels …*[1]

> *… as a comparative figure, between 10 000 and 15 000 coal miners are killed per annum around the world. China contributes largely to that, with over 6 000 deaths per annum in their coal mines. In comparison, in power stations, coal-fired power stations since 1997 have killed 6 500 people; natural gas, 1 200 people; hydro, 4 000 and maybe more … the nuclear industry has killed 31 people.*[2]

> *If you stood on the boundary of Lucas Heights for 24 hours a day, 365 days a year and breathed it all in, you would get about the same [radiation] dose as flying from Sydney to Melbourne …*[3]

> *The new millennium will see the increasing use of nuclear science and technology in every field of human endeavour. The immense benefits far outweigh the risks. And the risks of radiation must be assessed on a scientific basis and with informed realism … The manipulative assessment of nuclear risk must not deprive humanity of these immense benefits.*[4]

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1 Professor Leslie Kemeny, *Exhibit no. 9, Power to the people*, p. 2.

2 Mr Alan Eggers (Summit Resources Ltd), *Transcript of Evidence*, 3 November 2005, p. 3.

3 Dr Ron Cameron (Australian Nuclear Science and Technology Organisation), *Transcript of Evidence*, 13 October 2005, p. 16.

4 Professor Leslie Kemeny, *Exhibit no. 43*, *Pseudo-Science and Lost Opportunities*, p. 6.

Key messages —

- **The nuclear power industry has by far the best safety record of all major energy industries, including coal, oil, natural gas, liquefied petroleum gas and hydro.**
- **In the 20 years since the Chernobyl nuclear accident there have been some 60 deaths directly attributed to the accident—not all of which have been due to radiation exposure. In contrast, there are more than 10 000 deaths from coal mining accidents worldwide every year. This ignores the other deleterious health effects of burning fossil fuels, including through the ingestion of toxic gases and particulates. Even in Australia, which is said to have the safest mining industry in the world, 112 coal miners have died in NSW mines alone since 1979.**
- **Claims by some submitters that many thousands of people have already died as a result of the Chernobyl accident are massively exaggerated and are possibly intended to generate fear and further opposition to nuclear power. Whatever the motive, such claims are irresponsible and reflect poorly on the credibility of those individuals and groups making such claims.**
- **Among its other findings, a major multi agency UN report by the Chernobyl Forum concludes that the most pressing health problems for areas most affected by the Chernobyl accident is not radiation exposure but poor diet and lifestyle factors associated with alcohol and tobacco use, as well as poverty and limited access to health care.**
- **The Chernobyl Forum states that the largest public health problem caused by the accident has been the mental health impact, in part due to the trauma associated with the resettlement of large numbers of people from the most affected areas. The Chernobyl Forum states that 'misconceptions and myths' about the threat of radiation persist, promoting a 'paralysing fatalism' among residents.**
- **Notwithstanding the tragedy of Chernobyl, which has been the only accident to a commercial nuclear power plant that has resulted in loss of life, nuclear power's safety record is unrivalled by any other major energy source.**
- **The total average effective dose received by the world population from natural sources of radiation (i.e. 'natural background radiation') is 2.4 millisieverts (mSv) per year. In contrast, the total average effective dose to monitored workers across the whole nuclear fuel cycle (including uranium mining and milling) is 1.75 mSv per year.**

Aircrew in civil aviation are exposed to an average 3.0 mSv and radon exposure in some above-ground workplaces is estimated to average 4.8 mSv.

- **The maximum average annual radiation dose allowed for a uranium miner is currently set at 20 mSv. The actual dose received by workers at Australian uranium mines is well under half this level. The radiation exposure for the public in the vicinity of the mines is a small fraction of the prescribed limit for members of the public, which is 1 mSv.**
- **To provide greater assurance to uranium industry workers and the public at large, and also to definitively answer claims—which the Committee is confident are entirely mistaken—that current radiation exposures are harming workers, the Committee recommends the establishment of:**
  - ⇒ **a national radiation dose register for occupationally exposed workers; and**
  - ⇒ **a system of long-term monitoring of the health outcomes for workers occupationally exposed to radiation in uranium mining, associated industries and nuclear facilities.**
- **Occupational exposure, discharges from the nuclear industry and fallout from former atmospheric nuclear weapons tests accounts for approximately a quarter of one per cent of the total world average radiation exposure.**
- **The benefits of nuclear energy far outweigh the very small risks associated with radiation exposure from the routine operations of fuel cycle facilities, including uranium mining operations.**
- **In any case, health risks from the expanded use of nuclear power must be considered in the broader context of the risks associated with climate change and the certain health consequences of expanded use of fossil fuels.**
- **There is a clear need for improved public understanding of the nature of radiation and the actual exposures to the public from the nuclear industry's operations.**

Introduction

6.1 In this chapter the Committee examines the second key concern raised in opposition to the civil nuclear power industry—the safety of nuclear fuel cycle facilities, and particularly the health risks to workers and to the public from exposure to radiation from uranium mining and nuclear power plants.

6.2 The chapter presents evidence in relation to the following themes in turn:

- the health effects from exposure to ionising radiation and the current international standards for control of radiation exposure;
- regulation for radiation protection in Australia;
- safety and health issues associated with the uranium mining industry in Australia, specifically:
  - ⇒ radiation exposure to workers and the public from uranium mining operations;
  - ⇒ risks associated with the transport of uranium oxide in Australia;
  - ⇒ proposals for a national radiation dose register and long-term health monitoring of uranium industry and nuclear workers;
  - ⇒ safety at Australia's uranium mines;
- radiation exposure from the whole nuclear fuel cycle, including:
  - ⇒ exposures to nuclear industry workers;
  - ⇒ exposures to the public;
- nuclear safety, including:
  - ⇒ safety of nuclear reactors;
  - ⇒ global nuclear safety regime;
  - ⇒ fatalities associated with the Chernobyl accident;
  - ⇒ the safety record of the nuclear power industry compared to other energy sources;
  - ⇒ terrorism and the safety of nuclear facilities;
  - ⇒ use of depleted uranium munitions; and
- radiation and public perceptions.

Health effects of ionising radiation and international standards for control of exposure

6.3 The Committee introduced the concepts of ionising radiation and radiation exposure (or 'dose') at the beginning of the previous chapter. It was explained that ionising radiation, to which all living organisms are constantly exposed, has energy capable of causing chemical changes damaging to living tissue. Ionising radiation is of four types (alpha and beta particles, gamma rays and neutrons) and includes x-rays and the radiation from the decay of both natural and artificial radioactive substances.

6.4 Exposure measures the effect of radiation on substances that absorb it and is expressed in several ways, to account for the different levels of harm caused by different forms of radiation and the different sensitivity of body tissues. Among these measures is the 'equivalent dose', which refers to the effect of radiation exposure on human tissue and is measured by the 'Sievert' (Sv). The 'effective dose' takes into account what part of the body was exposed to radiation, because some organs are more sensitive to radiation than others. The effective dose is also measured by the Sievert.[5]

6.5 The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) reports that the total average effective dose received by the world population from all sources of radiation (natural and artificial) is 2.8 millisieverts (mSv—one thousandth of a Sievert) per year. Over 85 per cent of this total is from natural sources (primarily from buildings/soil, cosmic radiation, radon gas from the Earth and present in the air, and food). Of the sources of ionising radiation arising from human activities (i.e. artificial sources), the largest contributor is medical exposure from x-rays (0.4 mSv or 14 per cent of the total dose). Occupational exposure, discharges from the nuclear industry and fallout from former atmospheric nuclear weapons tests accounts for approximately a quarter of one per cent of the total world average radiation exposure (0.0072 mSv).[6] The contributions of natural and artificial sources to the world average annual effective radiation dose are listed in table 6.1.

6.6 The Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) explained that it is well known that doses of ionising radiation can cause harm. Extreme doses of radiation to the whole body (around 10 Sv and above), received in a short period, will cause so much damage to internal organs and tissues of the body that vital systems cease to function and death may result within days or weeks. Very high doses (between 1 Sv and 10 Sv), received in a short period, will kill large number of cells, which can impair the function of vital organs and systems. Acute health effects, such as nausea, vomiting, skin and deep tissue burns, and impairment of the body's ability to fight infection may result within hours to weeks. The extent of damage increases with dose. These types of radiation effects are referred to as 'deterministic' effects.[7]

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5 See: International Atomic Energy Agency, *Radiation, People and the Environment*, IAEA, Vienna, 2004, viewed 5 September 2006, <http://www.iaea.org/Publications/Booklets/RadPeopleEnv/pdf/radiation_low.pdf>.

6 *ibid.*, pp. 13, 14, 30; Professor Leslie Kemeny, *Exhibit no. 9, Power to the people*, p. 2.

7 ARPANSA, *Submission no. 32*, p. 7.

Table 6.1 Worldwide average annual effective radiation doses from natural sources and human activities in year 2000

Source	Worldwide average annual effective dose (mSv)
Natural background	2.4
Artificial sources (from human activities)	
Diagnostic medical examinations	0.4
Previous atmospheric nuclear weapons tests	0.005
Chernobyl accident	0.002
Nuclear power production	0.0002
Total from natural and human sources (rounded)	2.8

Source UNSCEAR, *Sources and Effects of Ionizing Radiation, Report to the UN General Assembly*, *2000*, *Volume I*, pp. 5, 8.

6.7 The International Atomic Energy Agency (IAEA or 'the Agency') explains that deterministic effects can be identified clinically to be the result of radiation exposure. They only occur if the dose or dose rate is greater than some threshold value, and the effect occurs earlier and is more severe as the dose and dose rate increase.[8]

6.8 While high radiation doses such as those mentioned above can cause harm, ARPANSA explained that there is continuing uncertainty about the effects at low doses. Doses below the thresholds for deterministic effects may cause cellular damage, but this does not necessarily lead to harm to the individual: the effects are said to be probabilistic or 'stochastic' in nature.[9]

6.9 The IAEA explains that stochastic effects are not certain to occur, but the likelihood that they will occur increases as the dose increases, whereas the timing and severity of any effect does not depend on the dose. Because radiation is not the only known cause of most of these effects, it is normally impossible to determine clinically whether an individual case is the result of radiation exposure or not.

6.10 The most important of the stochastic effects of radiation exposure is cancer. Ionising radiation is known to play a role in inducing certain types of cancer, for example by introducing mutations in the DNA of normal cells in tissues. These mutations can allow a cell to enter a pathway of abnormal growth that can sometimes lead to the development of a

8 IAEA, *op. cit.*, p. 15.

9 ARPANSA, *loc. cit.*

malignancy. Apart from cancer, the other main late effect of radiation is hereditary disease caused by genetic damage.[10]

6.11 It is known that doses above 100 mSv, received in a short period, lead to an increased risk of developing cancer later in life. Epidemiological evidence from survivors of the atomic bombs in Japan shows that, for several types of cancer, the risk of cancer increases roughly linearly with dose, and that the risk factor (which is the lifetime risk or radiation detriment assumed to result from exposure per unit dose) averaged over all ages and cancer types is about one in 100 for every 100 mSv dose.[11]

6.12 ARPANSA stated that at doses below 100 mSv the evidence of harm is not clear cut. It was observed that while some studies indicate evidence of radiation-induced effects, epidemiological research has been unable to establish unequivocally that there are effects of statistical significance at doses below a few ten of millisieverts. Given that no threshold for stochastic effects has been demonstrated, and in order to be cautious in establishing health standards, the proportionality between risk and dose observed at higher doses is presumed to continue through all lower levels of dose down to zero. This is called the linear, no-threshold (LNT) hypothesis and it is made for radiation protection purposes only.[12]

6.13 There is evidence that a dose accumulated over a long period carries less risk than the same dose received over a short period. Except for accidents and medical exposures, doses are not normally received over short periods, so that it is considered appropriate in determining standards for the control of exposure to use a risk factor that takes this into account. While not well quantified, a reduction of the high-dose risk factor by a factor of two has been adopted internationally, so that for radiation protection purposes the risk of radiation-induced fatal cancer (the 'risk factor') is taken to be about 1 in 20 000 per mSv of dose for the population as a whole.[13]

6.14 If the LNT hypothesis is correct, any radiation dose carries some risk. Therefore, measures for control of exposure for stochastic effects seek to avoid all reasonably avoidable risk, which is referred to as 'optimising protection'. The optimisation approach is underpinned by applying dose limits that restrict the risk to individual to an 'acceptable' level.[14]

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10 IAEA, *op. cit.*, pp. 16, 10.

11 ARPANSA, *op. cit.*, p. 8.

12 *ibid.*

13 This risk is usually expressed as five per cent per sievert. Recent data gathered by the ICRP would put the risk calculated on the same basis as 4.4 per cent per sievert.

14 *ibid.*

6.15 The International Commission on Radiological Protection (ICRP) has established recommended standards of protection (both for members of the public and radiation workers) based on three principles:

- Justification—no practice involving exposure to radiation should be adopted unless it produces a net benefit to those exposed or to society generally;
- Optimisation of protection—radiation doses and risks should be kept as low as reasonably achievable (ALARA), economic and social factors being taken into account; and
- Limitation of individual dose—the exposure of individuals should be subject to dose or risk limits above which the radiation risk would be deemed unacceptable.[15]

6.16 ARPANSA noted that determining what constitutes an 'acceptable' risk for regulatory purposes is a complex judgement. However, the ICRP's recommendations, which have in part been derived from studies of the Japanese survivors of the atomic bombs, have in general been internationally endorsed.

6.17 The *International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources* (BSS), published in 1996, are sponsored by the IAEA and five other international organisations including the World Health Organisation (WHO) and the International Labour Organisation (ILO).[16] The BSS, which are based primarily on the ICRP system of radiological protection described above, set out detailed requirements for occupational, medical and public exposures, and specify dose limits and exemptions. They also specify requirements for ensuring the safety of radioactive sources and for dealing with nuclear emergencies. IAEA Safety Guides give more detailed guidance on how the requirements should be met in particular situations.[17]

6.18 The BSS specifies that the additional effective dose above natural background and excluding medical exposure, should be limited to the following prescribed levels:

- 1 mSv in a year for members of the public; and
- 20 mSv per year averaged over five years for occupationally exposed persons, with no more than 50 mSv in any year.[18]

6.19 Citing a report by the 'European Committee on Radiation Risk', which is an organisation established by the Green Group in the European

15 Uranium Information Centre (UIC), *Submission no. 12*, p. 46; ARPANSA, *op. cit.*, p. 9.
16 ARPANSA, *op. cit.*, p. 9.
17 IAEA, *op. cit.*, p. 28.
18 ARPANSA, *loc. cit.*

Parliament, the Australian Conservation Foundation (ACF) argued that the dose limits prescribed by the ICRP were 'unacceptable' and that the total maximum permissible dose to members of the public arising from all practices should not be more than 0.1 mSv, with a value of 5 mSv for nuclear workers.[19]

The LNT hypothesis and radiation hormesis

6.20 Several submitters, including the Public Health Association of Australia (PHAA), Mr Justin Tutty and Dr Helen Caldicott argued that there is 'no known safe level at which radiation does not damage DNA and initiate cancer.'[20]

6.21 The MAPW (Victorian Branch) cited an article entitled *Risk of cancer after low doses of ionising radiation*, published in the British Medical Journal in June 2005. The article published the results of a study which sought to provide estimates of the risk of cancer after protracted low doses of ionising radiation, and involved a retrospective study of cohorts of workers in the nuclear industry (excluding uranium mining) in 15 countries. The study claimed to have been the largest ever conducted of nuclear workers, involving some 407 000 monitored workers. The report found that 1–2 per cent of deaths from cancer among the workers may be attributable to radiation. The results were said to indicate that there is a small excess risk of cancer, even at low doses and dose rates typically received by nuclear workers in the study. However, it was concluded that these estimates are higher than, but statistically compatible with, the risk estimates used for current radiation protection standards.[21]

6.22 In contrast, some submitters argued strenuously that very low doses of radiation may in fact have beneficial consequences for human health and questioned the appropriateness of the LNT hypothesis for radiation protection policies at these lower doses. Professor Ralph Parsons, a former President of the Australian Institute of Nuclear Science and Engineering (AINSE), former Member of the Uranium Advisory Council and past Chairman of the Australian Ionising Radiation Advisory Council, argued that there is evidence that low doses of radiation may in fact be beneficial to human health, an effect known as radiation hormesis:

> There is strong evidence to suggest that the estimated risks associated with low doses of ionising radiation have been grossly

19 ACF, *Submission no. 48*, p. 16.

20 Mr Justin Tutty, *op. cit.*, p. 5; Mr John Schindler, *Submission no. 10*, p. 1; Mrs Judy Forsyth, *Submission no. 74*, p. 2.

21 MAPW (Victorian Branch), *Exhibit no. 50, Risk of cancer after low doses of ionising radiation: retrospective cohort study in 15 countries,* pp. 1, 5.

> in error. One of the bases of radiation protection adopted by the International Commission for Radiological Protection is that the risk rises linearly with the dose from zero and there is no dose below which there is no risk. This is known as the Linear / No-Threshold or LNT hypothesis. During the last two decades extensive epidemiological and other studies have shown that the risk–dose relationship follows a J-curve; low doses are indeed beneficial in direct contradiction to the LNT hypothesis. The effect is known as Radiation Hormesis. Hormesis is a general term which covers, inter alia, the beneficial effects of small doses of agents as diverse as red wine, aspirin, and sunshine, all of which are harmful at high doses. For radiation the risk does not exceed the benefit until the dose exceeds many tens of millisieverts per annum; by comparison, the natural background in much of Australia is approximately two millisieverts per annum.[22]

6.23 Emeritus Professor Peter Parsons, also a former President of AINSE, submitted that the LNT model does not accord with effects on human health since, it was claimed, low doses of radiation protect against the harmful health effects observed at high doses. Specifically, it was argued that a low dose of radiation may stimulate DNA repair and the immune system, leading to protection against the deleterious health effects of radiation at higher exposures.[23] Consequently, it was argued that the LNT hypothesis is not an appropriate basis for policies of radiation protection for low doses:

> … solid scientific evidence for radiation hormesis extends back for many years. In March 2005, the French Academy of Sciences and National Academy of Medicine issued a comprehensive report based upon extensive human and experimental data published over many decades. This clearly shows that the LNT model cannot be validly used for assessing risks to populations at very low doses of radiation. In fact, the report finds that the LNT model overstates the harmful effects of low dose radiation, and stresses the importance of this conclusion for radiation protection.[24]

6.24 It was noted that background radiation in Australia is around two mSv per year. In contrast, in geological outliers elsewhere in the world, background exposures can be over 50 times higher. It was argued that hormetic affects of ionising radiation extend over this elongated range,

22 Professor Ralph Parsons, *Submission no. 24*, p. 1. See also: Dr Clarence Hardy (Australian Nuclear Association), *Transcript of Evidence*, 16 September 2005, p. 60.

23 Professor Peter A Parsons, *Exhibit no. 23, Radiation Phobia and Phantom Risks*, p. 1.

24 Professor Peter A Parsons, *Submission no. 34*, p. 1.

although additional demographic research would help to quantify this conclusion. It was concluded that:

> Peaceful uses of radiation are therefore unlikely to be deleterious. While I do not have detailed knowledge of uranium mining and handling processes, radiation exposures are apparently towards the lower end of the hormetic range, implying no consequent biological or health reasons against the development of Australia's uranium resources.[25]

6.25 Professor Parsons also argued that the low risk associated with radiation exposure in nuclear power generation needs to be compared with the very serious health risks associated with global warming:

> This low-risk, or phantom-risk, situation should be viewed in the light of the progressive increase in greenhouse gases especially carbon dioxide, with their potential for climatic change and deleterious biological and health consequences.[26]

6.26 Despite these observations about radiation hormesis, ARPANSA stated that there is some epidemiological evidence that there are risks to health from lower doses of radiation, down to about 20 mSv. While the evidence of health effects from doses lower than this is uncertain, ARPANSA submitted that the 'safest view is that the effect is linear down to very low levels.'[27] That is, that the LNT hypothesis is the most prudent basis for radiation protection policy.

Australia's national regulatory framework

6.27 Established under the *Australian Radiation Protection and Nuclear Safety Act 1998* (ARPANS Act), ARPANSA is responsible for protecting the safety and health of people, and the environment, from the harmful effects of ionising and non-ionising radiation.

6.28 Among its other functions, ARPANSA seeks to:

- promote the uniformity of radiation protection and nuclear safety policy and practices across jurisdictions of the Commonwealth, the states and territories;
- provide advice to Government and the community on radiation protection, nuclear safety and related issues; and

25 *ibid.*, p. 2.

26 *ibid*.

27 Dr John Loy (ARPANSA), *Transcript of Evidence*, 16 September 2005, p. 77.

- undertake research and provide services in relation to radiation protection, nuclear safety and medical exposures to radiation;
- regulating radiation protection and nuclear safety aspects of all Commonwealth entities involved in radiation or nuclear activities and dealings; and
- lead the development of standards, codes of practice, guidelines and other relevant material to support radiation protection and nuclear safety throughout Australia.[28]

6.29 The ARPANS Act establishes the Chief Executive Officer (CEO) of ARPANSA (currently Dr John Loy) as the regulator of: the construction and operation of nuclear installations or prescribed radiation facilities; and dealings with radiation sources by 'controlled persons', which are Commonwealth entities (Commonwealth Department, agency or body corporate or Commonwealth controlled company) or Commonwealth contractors.

6.30 While ARPANSA does not have a direct role in regulation for radiation protection of current uranium mining in Australia, which is a responsibility of the state governments, it plays a major part in establishing the national framework for radiation protection applying, inter alia, to uranium mining and milling. Regulation for radiation protection in the mining and milling of uranium, as for radioactive waste management, takes place primarily through state/territory legislation. Radiation protection provisions are principally based upon national codes of practice and standards listed below, which in turn draw upon the international guidance described above.[29]

6.31 The ARPANS Act has established a Radiation Health and Safety Advisory Council and a Radiation Health Committee. The Council has the functions of identifying emerging issues and matters of major concern to the community and advising the CEO on them, while the Radiation Health Committee's functions are to:

- advise the CEO and the Council on matters relating to radiation protection;
- develop policies and to prepare draft publications for the promotion of uniform national standards of radiation protection;
- formulate draft national policies, codes and standards in relation to radiation protection for consideration by the Commonwealth, states and territories;

28 ARPANSA, *op. cit.*, p. 2.

29 *ibid.*, pp. 3, 4. Department of the Environment and Heritage, *Submission no. 55*, p. 22.

- from time to time to review national policies, codes and standards in relation to radiation protection to ensure that they continue to substantially reflect world best practice; and
- to consult publicly in the development and review of policies, codes and standards in relation to radiation protection.[30]

6.32 The members of the Radiation Health Committee are: the CEO of ARPANSA; a 'radiation control officer' from each state and territory; a representative of the Nuclear Safety Committee (also established under the ARPANS Act); a person to represent the interest of the general public; and up to two other members.

6.33 ARPANSA publishes a Radiation Protection Series to promote practices that protect human health and the environment from the possible harmful effects of radiation. The Series includes all radiation protection Codes of Practice, Safety Guides and Recommendations.

6.34 The Radiation Health Committee has recommended that the international radiation protection standards described above be adopted in Australia. The radiation protection principles and recommended standards for Australia are given in ARPANSA/National Occupational Health and Safety Commission (NOHSC) Radiation Protection Series Number One: *Recommendations for Limiting Exposure to Ionizing Radiation* and the *National Standard for Limiting Occupational Exposure to Ionizing Radiation* (republished 2002).[31]

6.35 In addition, a *Code of Practice and Safety Guide for Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing* (2005) provides a uniform framework for radiation protection in the mining and mineral processing industries in Australia, as well as for the management of radioactive waste arising from mining and mineral processing. Compliance with the Code is a requirement of authorisations issued by the NT Government or licences by the SA Government for the mining of uranium.[32] Dr Loy explained that the Code and Safety Guide refect the radiation protection principles outlined above:

> These are the need for justification of any practice involving exposure to ionising radiation; the optimisation of protection to ensure that exposures are as low as reasonably achievable, economic and social factors being taken into account—and this is

30 *ibid*., p. 3.

31 ARPANSA/NOHSC, *Recommendations for Limiting Exposure to Ionizing Radiation* and *National Standard for Limiting Occupational Exposure to Ionizing Radiation,* ARPANSA, Sydney, 2002, viewed 12 September 2006, <http://www.arpansa.gov.au/pubs/rps/rps1.pdf>.

32 ARPANSA, *Exhibit no. 67*, *Code of Practice and Safety Guide for Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing*.

> called ALARA in the trade—and the limitation of individual doses.[33]

6.36 The transport of radioactive materials in Australia, including uranium, is addressed in a code of practice for the safe transport of radioactive material which adopts international transport requirements.

6.37 The UIC explained that responsibilities for administration of the Code are held by relevant agencies in the states and territories. This includes ensuring that the basic radiation exposure standards are complied with, day-to-day oversight of the general occupational health and safety requirements at mine sites, and regular reporting of monitoring results.[34]

6.38 In August 1999 the Australian Health Ministers' Conference (AHMC) endorsed the development of a *National Directory for Radiation Protection*, which is intended to provide an agreed overall framework for radiation safety, including both ionising and non-ionising radiation, together with clear regulatory statements to be adopted by the Commonwealth, states and territories. The Directory is intended to be the means for achieving uniformity in radiation protection practices between jurisdictions. The AHMC agreed that, following consideration and approval of the provisions, the regulatory elements of the Directory shall be adopted in each jurisdiction as soon as possible. The first edition of the Directory was approved by Ministers in July 2004. APANSA explained that it is hoped that the second edition of the Directory, planned for completion in 2006, will incorporate the new Code and deal with matters relevant to mining and minerals processing.[35] Dr Loy explained that:

> … it is hoped that the code and the safety guide will be adopted by states and territories through being included in … the National Directory for Radiation Protection, the second edition of which is being prepared.'[36]

33 Dr John Loy, *op. cit.*, p. 70.

34 UIC, *op. cit.*, p. 47.

35 See: ARPANSA, *National Directory for Radiation Protection – Edition 1.0*, ARPANSA, Melbourne, 2004, viewed 12 September 2006, <http://www.arpansa.gov.au/pubs/rps/rps6.pdf>; ARPANSA, *Submission no. 32*, pp. 6–7.

36 Dr John Loy, *loc. cit.*

Safety and health issues associated with the uranium industry in Australia

Radiation exposure to workers and the public from uranium mining

6.39 Mining and milling of uranium ores can lead to external and internal exposure of workers and the public to radiation. External exposure results from exposure to gamma rays from the radionuclides in the ore as it is mined and processed. Internal exposure arises from the inhalation of radon gas and its decay products and of radionuclides in the ore dust. ARPANSA explained that the extent of internal exposure will depend on the ore grade, the airborne concentrations of radioactive particles (which will vary with the type of mining operation and the ventilation) and the particle size distribution. The total internal exposure is generally of greater importance in underground mines than in open-pit mines.[37]

6.40 Several submitters opposed further uranium mining on the basis of radiation exposures and other health effects, with the MAPW (WA Branch) arguing that: 'The health consequences of uranium mining and nuclear power are on their own enough reason to spurn any increase in uranium mining/nuclear power.'[38] Mr Daniel Taylor claimed that: 'By allowing the mining and export of uranium, the Australian government is liberating vast quantities of radiation'.[39]

6.41 Dr Helen Caldicott claimed that, in the past, one third of uranium miners died of lung cancer:

> Uranium is radioactive. When you mine it, gamma radiation is emitted from the ore face. The men who mine uranium are exposed to gamma radiation, like X-rays, all the time, which can damage the ordinary bodies cells, to cause cancer, and damage the sperm. Uranium decays to a series of daughters, one of which is radon, which is an alpha emitter … If you inhale radon into your lung, it lands in the terminal air passage and can irradiate a few cells for many years—such that one-third of men who have, in the past, mined uranium around the world have died of lung cancer.[40]

6.42 Similarly, Ms Janet Marsh claimed that:

> The history of uranium mining is marked by a high incidence of lung cancer amongst miners, caused by unavoidable inhalation of

37 ARPANSA, *Submission no. 32*, p. 10. Dr G Mudd, *Exhibit no. 14, Uranium Mill Tailings Wastes in Australia*, p. 1.

38 MAPW (WA Branch), *Submission no. 8*, p. 2. See also: B K Daly-King, *Submission no. 3*, p. 1.

39 Mr Daniel Taylor, *Submission no. 85*, p. 17. See also: Mrs Judy Forsyth, *Submission no. 74*, p. 2.

40 Dr Helen Caldicott, *Transcript of Evidence*, 16 September 2005, pp. 2–3.

> radioactive radon gas, a highly radioactive gas given off by uranium deposits. There is no 'safe' dose of radon. Low dose ionizing radiation may well be the most single cause of cancer, birth defects and genetic disorders. There cannot be a 'safe' dose of radiation, there is no 'safe' threshold. Knowing this, then any permitted radiation is a permit to commit murder.
>
> Miners are also exposed to increased whole body radiation from the ore itself, causing cancers, sterility, and the genetic mutations which are detrimental to the species and passed on to countless future generations.[41]

6.43 The Public Health Association of Australia (PHAA) called for an end to uranium mining, stating that:

> The public health effects of radioactive (radon gas and air-borne radioactive particulates) and non-radioactive (eg molybdenum) contamination release from uranium mines has not been well studied yet … The PHAA has continuing concerns in the area of occupational health effects of uranium mining, including dose-related increase of risk of lung cancer (with no safe lower threshold of exposure), as this effect is synergistic with the effects of tobacco smoking. Non radiation related occupational health effects are similarly of concern. These are the same as for other mining in general and include injury, lung diseases and hearing loss.[42]

6.44 Similarly, Dr Gavin Mudd submitted that:

> … the release of radionuclides into the environment or changes in ionising radiation rates are still poorly quantified from uranium mining and milling, despite some improvements in recent years.[43]

6.45 The Gundjeihmi Aboriginal Corporation (GAC), representing the Mirarr people, Traditional Owners of the land on which the Ranger mine is located in the Northern Territory (NT), submitted that many of the Indigenous people near the mine are fearful that the bush food and land is being contaminated, and that people living downstream of the mine may face risks of contamination:

> A fundamental concern of the Mirarr is that uranium mining, both during operation and after rehabilitation, could lead to increased concentrations and loads of radionuclides released in the

41 Ms Janet Marsh, *Submission no. 2*, p. 1.

42 PHAA, *Submission no. 53*, p. 4.

43 Dr Gavin Mudd, *Exhibit no.18, Uranium mining in Australia: Environmental impact, radiation releases and rehabilitation*, p. 9.

> environment compared to pre-mining conditions, as well as possibly higher radiation rates due to the operations undertaken.[44]

6.46 In contrast, the Mr Ian Hore-Lacy, General Manager of the Uranium Information Centre (UIC), argued that:

> The industry has demonstrated that it can mine its uranium in a safe and environmentally responsible way, safe for the workers directly involved in the industry, and safe and with minimal environmental impact for the wider community.[45]

6.47 More specifically, the UIC argued that

- there have been more than 40 years of experience in applying international radiation safety regulations at uranium mines;
- Australian radiation safety regulations today are among the most comprehensive and stringent in the world;
- radiation doses at Australian uranium mines are well within regulatory limits; and
- uranium mining companies have taken active steps to reduce radiation doses wherever and whenever they can, and have voluntarily adopted the most recent international recommendations on dose limits long before they became a regulatory requirement.[46]

6.48 The UIC also argued that uranium mining does not discernibly increase the amount of radiation to which members of the public are exposed, including communities living near uranium mines.

6.49 The Association of Mining and Exploration Companies (AMEC) submitted that:

> Uranium mining companies have taken active steps to reduce possible radiation risk below international standards. Australian companies have voluntarily adopted the most recent international recommendations on safe radiation levels, published by the International Commission on Radiological Protection (ICRP), without waiting for a revision of the 1987 Health Code in Australia. Maximum actual exposure levels at Australian mines are about half those specified, and average levels are little more than from natural background.[47]

6.50 Similarly, Summit Resources submitted that:

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44 GAC, *Submission no. 44*, p. 36.

45 Mr Ian Hore-Lacy (UIC), *Transcript of Evidence*, 19 August 2005, p. 89.

46 UIC, *Submission no. 12*, p. 45.

47 AMEC, *Submission no. 20*, p. 4.

> There is no evidence of safety as an issue. With over 50 years of uranium mining in Australia, and currently large underground mines operating, there has been full compliance with international radiation safety regulations and standards. Constant monitoring shows maximum actual exposure levels at Australian mines about half those specified and, average levels, little more than natural background.
>
> Importantly, to our knowledge, there has been no exposure of any mine or process plant personnel to unsafe radiation levels reported from Australia's uranium mines, or ongoing issues related to the health of current or former uranium mine workers.[48]

6.51 In terms of the actual radiation doses received by uranium mine workers, ARPANSA submitted that Australian data reported to the UNSCEAR for 1991–1994 and reported in UNSCEAR's report to the UN General Assembly in 2000, shows that the average annual effective dose to measurably exposed workers from uranium mining was 1.43 mSv, down from 4.11 mSv reported for 1985–1989. The world average reported for 1990–1994 was 5.39 mSv. The average annual effective dose to measurably exposed workers from uranium milling in Australia was 0.55 mSv for 1991–1994, down from 3.36 mSv for 1985–1989. The average dose reported worldwide for 1990–1994 was 1.25 mSv [49]

6.52 ARPANSA's Personal Radiation Monitoring Service (PRMS) has published the annual photon (i.e. external) doses monitored by the PRMS during 2004 for uranium mining, as listed in table 6.2. These results show that most uranium mine workers are receiving external radiation doses below 2 mSv with a maximum dose of 7.7 mSv for miners and 2.9 mSv for mill workers.

Table 6.2 Annual external radiation doses received by Australian uranium mine workers in 2004

Occupational Classification	Quartile doses in microsieverts* (µSv)			Maximum dose (µSv)	Average dose (µSv)	No of wearers
	Q1	median	Q3			
Uranium mine workers	260	900	1 710	7 770	1 125	583
Uranium mill workers		740	1 780	2 950	977	49
Miscellaneous		60	310	2 600	302	89

Source ARPANSA, *Submission no. 32*, p. 10.
* A micosievert (µSv) is one millionth of a Sievert.

48 Summit Resources Ltd, *Submission no. 15*, p. 33.

49 ARPANSA, *loc. cit.*

6.53 The UIC likewise submitted that radiation dose records compiled by mining companies have shown consistently that mining company employees are not exposed to radiation doses in excess of the regulatory limits. It was argued that the maximum dose received in Australia is about half the 20 mSv per year limit.

6.54 Radiation monitoring at the three operating uranium mines and in the surrounding areas shows the following radiation exposures for 2005:

- Ranger—the company's 250 designated employees (i.e. those employees in work categories that have the potential to exceed 5 mSv per year) received an average dose of 1.0 mSv during 2005. Non-designated employees received a maximum dose of 0.9 mSv in 2005. The exposure of residents of the Jabiru township and surrounding communities attributable to the mine was assessed as 0.04 mSv in 2005. The natural background radiation in the area is 2–3 mSv.[50]
- Olympic Dam—for the year 2005–06 the average dose to all designated employees in the mine was 3.5 mSv, while the highest dose received by an individual was 7.7 mSv. The exposure of residents of the Roxby Downs township attributable to the mine was calculated to be 0.018 mSv.[51]
- Beverley—the company's 247 employees received an average effective dose of 0.48 mSv in 2005, with the maximum dose received being 3.84 mSv. The dose to members of the public, who reside temporarily at the North Mulga Homestead and at the Beverley Accommodation Camp, was calculated at less than 0.01 mSv in 2005.[52]

6.55 The lower dose figures for Beverley are largely explained by the nature of the mining operation. Heathgate Resources, owners of the Beverley mine, explain that because Beverley is an in-situ leach (ISL) operation, the reduced dust and absence of exposure to ore means greatly reduced radiation exposure to workers and the public. Radon, the gas released into the atmosphere in underground and open cut mines is less prevalent in an ISL mine. This is because the ore is left in-situ and not exposed. There is no dust associated with the mining process and the ore is not crushed or

50 Energy Resources of Australia Ltd (ERA), *Social and Environmental Report 2005*, ERA, Darwin, 2006, p. 15, viewed 13 September 2006, <http://www.energyres.com.au/corporate/ERA_SE_Rep05ART.pdf>.

51 Information provided by Mr Richard Yeeles (BHP Billiton Ltd), 13 September 2006. Information available in the *Olympic Dam Radiation Protection Annual Report* (August 2006) provided to the South Australian Government.

52 Information provided by Ms Nicole Allen (Heathgate Resources Pty Ltd), 13 September 2006. See also: Heathgate Resources Pty Ltd, *Annual Environmental Report 2005*, Heathgate Resources Pty Ltd, Adelaide, 2005, p. 32, viewed 13 September 2006, <http://www.heathgateresources.com.au/contentsustainability.jsp?xcid=452>.

ground in processing. There are no tailings dams or waste rock-piles, nor are there any ore stockpiles at Beverley.[53]

6.56 The results for Australia's uranium mines indicates that, based on current data, exposure for workers is well under half the prescribed annual (average) limit for workers of 20 mSv. Furthermore, the radiation exposure for the public in the vicinity of the uranium mines is also far below the prescribed level of 1 mSv. Indeed, at Beverley, the nearest members of the public received a dose less than one hundredth the prescribed limit in 2005.

6.57 Furthermore, the UIC argued that doses are minimised by programs of eduction and training, as well as engineering design of mining and processing operations. Among the exposure management techniques to protect workers, UIC and the Minerals Council of Australia (MCA) pointed out that:

- dust is controlled, so as to minimise inhalation of gamma or alpha-emitting minerals. In practice, dust is the main source of radiation exposure in an open cut uranium mine and in the mill area;
- radiation exposure of workers is minimal in an open cut mine because there is sufficient natural ventilation to remove the radon gas. At Ranger (an open cut mine in the Northern Territory), the radon level seldom exceeds one percent of the levels allowable for continuous occupational exposure. In an underground mine, as at Olympic Dam in South Australia, a good forced-ventilation system is required to achieve the same result; and
- strict hygiene standards are imposed on workers handling uranium oxide concentrate (UOC). If UOC is ingested it has a chemical toxicity similar to that of lead oxide. In effect, the same precautions are taken as in a lead smelter, with use of respiratory protection in particular areas identified by air monitoring. At Olympic Dam, packing uranium oxide concentrate is automated, so no human presence is required.[54]

6.58 The Committee notes that in relation to the hazards associated with mining and milling uranium, the seminal Ranger Uranium Environmental Inquiry (the Fox Inquiry report) also concluded that:

> … we are quite satisfied that, if properly regulated and controlled according to known standards, those operations do not constitute

53 See: Heathgate Resources Pty Ltd, *Occupational Health and Safety*, viewed 13 September 2006, <http://www.heathgateresources.com.au/contentsustainability.jsp?xcid=356>.

54 UIC, *op. cit.*, p. 46; MCA, *Submission no. 36*, p. 18.

any health hazard which is greater in degree than those commonly accepted in everyday industrial activities.[55]

6.59 Mr Andrew Crooks argued that the Australian Government should seek the adherence to international safety and environmental standards by those countries with uranium resources, so that the competitiveness of Australian producers is not threatened by an 'uneven playing field' in these matters.[56]

Risks associated with transport of uranium in Australia

6.60 As noted in the previous chapter, the transport of radioactive material in Australia, including uranium oxide, is conducted according to the Australian *Code of Practice for the Safe Transport of Radioactive Material* (2001), which effectively adopts international transportation requirements established by the IAEA.[57] The Code has been adopted by all the states and territories with the exception of Victoria, which ARPANSA notes is now moving to adopt the Code. Among other elements, the Code establishes: provisions about a radiation protection program; emergency response; quality assurance; compliance assurance; requirements for packages (e.g. transportation casks) and definitions of package types.[58]

6.61 Responsibility for enforcement of requirements for the physical protection (PP) of nuclear materials in Australia is the responsibility of the Australian Safeguards and Non-Proliferation Office (ASNO) under the *Nuclear Non-Proliferation (Safeguards) Act 1987*.

6.62 It was explained that under the *Convention on the Physical Protection of Nuclear Materials (1979)* (CPPNM), the IAEA has issued detailed guidance on the physical protection of nuclear materials and nuclear facilities. This guidance aims: 'To establish conditions which would minimize the possibilities for unauthorised removal of nuclear material and/or for sabotage.'[59] ASNO explained that Australia applies these requirements domestically and, through its bilateral safeguards agreements, requires customer countries to do the same. In July 2005 major amendments to the CPPNM were agreed that will strengthen the Convention and these amendments make it legally binding for States Parties to protect nuclear

55 Mr R W Fox, *Ranger Uranium Environmental Inquiry First Report*, AGPS, Canberra, 1976, p. 176.

56 Mr Andrew Crooks, *Submission no. 84*, p. 10.

57 See: ARPANSA, *Code of Practice for the Safe Transport of Radioactive Material,* 2001, viewed 29 August 2006, <http://www.arpansa.gov.au/pubs/rps/rps2.pdf>.

58 ARPANSA, *Submission no. 32*, pp. 5–6.

59 Cited in the Hon Alexander Downer MP, *Submission no. 33*, p. 9.

facilities and material in peaceful domestic use, storage as well as transport.[60]

6.63 It was explained that maintaining effective control over uranium requires that uranium is available only to authorised persons and that there are appropriate levels of PP at the mines themselves and the UOC stored there. ASNO sets out specific PP requirements and inspects the mines annually. ASNO also requires the uranium mines to adopt and report on specific procedures to ensure appropriate levels of physical protection for shipments of UOC from Australia to the port of unloading overseas. These procedures include checking on the physical condition of the containers and verifying the container and seal numbers at each port of unloading or transhipment.[61]

6.64 ASNO also submitted that it commissioned a thorough security risk review of uranium and its transport in Australia, the final report of which was expected in mid-2005. By virtue of its role as the provider of protective security advice to the Australian Government, ASIO was selected to conduct this work which included a National Security Threat Assessment. While it was expected that the ASIO report would bring forward some recommendations to further strengthen the protective security arrangements at the mines and during transport against currently perceived threats, the review identified no significant shortcomings. This result was said to be expected given that the current (terrorist) threat to UOC infrastructure remains (very) low and because UOC is weakly radioactive, meaning there would be minimal radiological consequences arising from any incident occurring during transport.[62]

6.65 Similarly, while the issue of the possible use of UOC in so-called 'dirty bombs' (radiological dispersal devices) is addressed more fully in chapter eight, ARPANSA and the Australian Nuclear Science and Technology Organisation (ANSTO) argued that because of the low levels of radioactivity in uranium oxide, use of natural uranium in such a device would not present any hazard to human health:

> … it is considered that the use of natural uranium, such as is processed and transported by the uranium mining industry, would not present any hazard to persons or the environment if used by terrorists with malicious intent.[63]

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60 IAEA, *States Agree on Stronger Physical Protection Regime*, Press Release, 8 July 2005, viewed 26 July 2006, <http://www.iaea.org/NewsCenter/PressReleases/2005/prn200503.html>.

61 The Hon Alexander Downer MP, *op. cit.*, p. 8.

62 *ibid*.

63 ARPANSA, *Submission no. 32*, p. 11; ANSTO, *Submission no. 29*, p. 20.

6.66 Furthermore, in relation to the hazards associated with transporting uranium oxide in Australia, Eaglefield Holdings submitted that:

> Yellowcake is actually about the least hazardous of all commodities that you can put on the back of a truck. By way of analogy, countless truck loads of sodium cyanide are shipped to the [Western Australian] goldfields each year. Each one of those truck loads of sodium cyanide would be 1,000 times more dangerous than a truck load of yellowcake … All it goes to show is that those who would oppose uranium mining in Western Australia have succeeded in the public relations war up until now. Yellowcake is almost entirely benign. It emits alpha radiation in very small quantities.[64]

6.67 Eaglefield went on to argue that:

> … moving a truck load of uranium around Western Australia is far safer than moving a truck load of smoke detectors … The active product in the smoke detector is an isotope called americium-241. Americium-241 was discovered during the Manhattan Project, which is why it is called americium. Americium-241 is a decay product of plutonium-241. Plutonium-241 is a product that is recovered from the reprocessing of high-level nuclear waste. Plutonium-241 can only be produced in a nuclear reactor.[65]

National radiation dose register and long-term health monitoring

6.68 Despite the radiation dose evidence presented above, which shows that doses received by uranium mine workers in Australia are well below the prescribed limit, some concern was expressed that Australia does not monitor the long-term health outcomes for uranium industry workers and other occupationally exposed persons. For example:

- MAPW (WA Branch) argued that Australia does not have a 'proper system of monitoring the long-term health of miners. The result is that we do not really know how much damage is being done.'[66]
- Dr Caldicott remarked that:

> None of our uranium miners have ever been followed up—from Rum Jungle, Mary Kathleen or anywhere else—to see,

64 Mr Michael Fewster (Eaglefield Holdings Pty Ltd), *Transcript of Evidence*, 23 September 2005, p. 32.

65 *ibid*., p. 34.

66 Dr Peter Masters (MAPW – WA Branch), *Transcript of Evidence*, 23 September 2005, p. 44.

> epidemiologically, if they have an increased incidence of cancer, and that is irresponsible on the part of our governments.[67]

- Mr John Schindler argued that 'no long-term health studies of workers who have been employed in uranium mining have been undertaken.'[68]

6.69 The Construction, Forestry, Mining and Energy Union (CFMEU), which noted that it does not represent any uranium mining workers, called for long-term monitoring of the health of uranium mine workers.[69] Similarly, the PHAA called for the establishment of a:

> … national register of all uranium industry workers who have been exposed to radiation to enable appropriate medical care and study of the occupational health effects of uranium mining and milling.[70]

6.70 Likewise, Friends of the Earth–Australia (FOE) argued that:

> There remains no government collection of records to assess long-term health impacts to workers. Given the health impacts now associated with asbestos mining, long-term health assessment should be a public duty of care.[71]

6.71 In relation to the monitoring of doses received by radiation workers, including designated uranium mine and mill workers, the *National Standard for Limiting Occupational Exposure to Ionising Radiation* states that:

> Records of doses assessed to have been received by an employee, including details of monitoring results and dose calculation methods, as required by the appropriate authority, shall be kept during the working life of the employee and afterwards for not less than 30 years after the last dose assessment and at least until the employee reaches, or would have reached, the age of 75 years. When an operation terminates, the employer shall pass to the appropriate authority the retained records of doses assessed to have been received by employees and any other records specified by the appropriate authority.[72]

6.72 ARPANSA explained that regulatory agencies in each state and territory accord with the national standard, requiring uranium mining companies

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67 Dr Helen Caldicott, *op. cit.*, p. 3.

68 Mr John Schindler, *Submission no. 10*, p. 1. See also: MAPW (Victorian Branch), *Submission no. 30*, p. 15. See also: Alice Action Executive Committee, *Submission no. 79*, p. 1.

69 CFMEU, *Exhibit no. 11, Submission by CFMEU to Senate Environment Committee*, p. 7.

70 PHAA, *Submission no. 53*, p. 4.

71 FOE, *Submission no. 52*, p. 9.

72 ARPANSA/NOHSC, *op. cit.*, p. 75.

to keep dose records for employees for not less than 30 years. For example, in jurisdictions with operating mines:

- In South Australia, Regulation 26(4) of the Ionizing Radiation Protection and Control (Ionising Radiation) Regulations 2000 (made under the *Radiation Protection and Control Act 1982*) provides that a specified employer must not destroy or dispose of any records kept under the regulation (which includes records of the personal radiation exposure for each radiation worker) except with the approval of the Minister. The South Australian regulator advised that to date, the Minister has not received an application from any specified employer to destroy such records.
- In the Northern Territory, section 26 of the *Radiation (Safety Control) Act 1999* requires employers of radiation workers to keep records of radiation doses received by each of its radiation workers. Employers of radiation workers must also comply with the *National Standard for Limiting Occupational Exposure to Ionizing Radiation*, requiring that records of doses received by employees must be kept during the working life of the employee and afterwards for not less than 30 years after the last dose assessment and at least until the employee reaches the age of 75.[73]

6.73 ARPANSA stated that collection of up-to-date data for total radiation doses received by uranium mine workers is complicated by the fact that the dose a miner receives is made up the direct dose from the gamma rays from the radioactive material and, second, the internal dose from the inhalation of radon gas and from inhaling or ingesting dust. The internal doses are difficult to measure. However, this data is collected by the companies concerned and ARPANSA's practice is to approach the companies 'every five years or so' to collate the data.[74]

6.74 BHP Billiton noted that it has 'quite an extensive program of monitoring employees' at Olympic Dam, particularly those designated employees exposed to radiation in the course of their duties.[75] The company provides relevant information to government every quarter for the designated employees.

6.75 However, BHP Billiton stated that regular monitoring of workers' health was not necessary:

> The radiation limits are set at a point that that is not required. If you are below those limits, the risk factor is equivalent to being a

73 ARPANSA, *Submission no. 32.1*, p. 2.

74 Dr John Loy, *op. cit.*, p. 75.

75 Dr Roger Higgins (BHP Billiton Ltd), *Transcript of Evidence*, 2 November 2005, p. 19.

> bricklayer or a painter. The same would apply if you were a bricklayer and you ceased employment with a construction company. Would the construction company then follow you for the rest of your life? The same theory applies. I think the discussions come up every two to five years, but there has been no recent discussions on that.[76]

6.76 In addition, BHP Billiton argued that it would be administratively very complex to track former employees:

> It is quite an administrative nightmare to try and track people, even while they are working with us … For them to be tracked when they leave employment and disappear to wherever in the world would be very difficult exercise.[77]

6.77 For its part, the MCA submitted that the minerals industry is working closely with the Minerals Industry Safety and Health Centre (MISHC) in determining the practicality of tracking the health of workers in the minerals industry.[78]

6.78 The Committee notes that the establishment of a national radiation dose register for occupationally exposed persons has previously been proposed to the Federal Government and not implemented. Dr Loy explained that the states opposed the establishment of such a register:

> … the states recommended through the Radiation Health Committee that we not proceed with such a register. I think fundamentally their view was based upon the fact that what we know of the doses is such that they are not likely to lead to any further knowledge of the effects of radiation on human health because the level of dose is low and the number of workers is relatively small.[79]

6.79 ARPANSA submitted that the Radiation Health Committee did not support the development of such a register but agreed with the collection and supply of data to UNSCEAR:

> The Committee's view was formed on the basis that the level of doses being received and likely to be received in Australia, together with the number of exposed workers, meant that there was no value in a register from the point of view of any study of health effects.[80]

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76 Mr Steve Green (BHP Billiton Ltd), *Transcript of Evidence*, 2 November 2005, p. 19.

77 *ibid*., pp. 19–20.

78 MCA, *op. cit*., p. 17.

79 Dr John Loy, *op. cit*., p. 76.

80 ARPANSA, *op. cit*., p. 10.

6.80 ARPANSA noted, however, that a radiation dose register could have merit and may be worth revisiting:

> On the other hand, you could argue that, for a sense of security and support for workers in the uranium mining industry, a dose registry would be something that would be appropriate. We would certainly be open to the suggestion that we should go back and revisit that, focusing on mining workers and perhaps some other workers who receive small but measurable doses, rather than having a national dose register for people who work very briefly with radiation and do not get very much exposure at all. I think we need to narrow down the terms of reference a little bit to make it manageable.[81]

6.81 The Committee notes the various views put to it in relation to the need for, and potential merits of, establishing a national radiation dose register and long-term health monitoring of occupationally exposed persons in Australia. The Committee accepts that the doses received by occupationally exposed workers in Australia are small and are highly unlikely to be injurious to health. However, there remains the important issue of public perceptions of the safety of the industry and its impacts on workers exposed to radiation. The matter of providing assurance to workers themselves is also important.

6.82 In view of the potential expansion of the industry and the claims, however erroneous, that the health of workers' is being compromised by uranium mining and the nuclear industry more generally, the Committee recommends that a national radiation dose register be established. The Committee further recommends that the long-term health outcomes of occupationally exposed workers, or an appropriate sample of such workers, be monitored. Such a monitoring regime could involve periodic medical assessments over the lives of cohorts of occupationally exposed workers. In this way, the Committee hopes not only to provide assurance to workers and the public at large, but also to definitively answer claims—which the Committee is confident are entirely mistaken—that current radiation exposures are harming workers.

6.83 The Committee accepts that the scope of the register and health monitoring program would need to be carefully considered in order to ensure manageability. For example, the Committee's intention is not to include workers engaged in medical uses of radiation. However, the Committee urges that all uranium mine workers and other occupationally exposed workers, including workers at Lucas Heights and any other

81 Dr John Loy, *loc. cit.*

nuclear facilities that may be established in Australia over time, be included in the monitoring program. It is hoped that these initiatives can build on monitoring currently undertaken.

6.84 The Committee notes the observation by BHP Billiton that a long-term health monitoring program could be administratively complex. The Committee wishes to minimise any additional burdens on industry and therefore recommends that the monitoring program be funded jointly by governments and industry. The Committee also urges that industry be closely consulted as to the operation of the program.

Recommendation 3

To provide greater assurance to workers and the public at large, and also to definitively answer claims—which the Committee is confident are entirely mistaken—that current radiation exposures are harming workers, the Committee recommends that the Australian Government, in conjunction with state governments and industry, establish:

- **a national radiation dose register for occupationally exposed workers; and**
- **a system of long-term monitoring of the health outcomes for workers occupationally exposed to radiation in uranium mining, associated industries and nuclear facilities.**

The Committee further recommends that the Australian Government:

- **jointly fund the health monitoring program with industry; and**
- **periodically publish the monitoring data, indicating any link between radiation exposures and health outcomes for these workers.**

Incidents at Australia’s uranium mines

6.85 Some submitters drew the Committee’s attention to two incidents that took place at Ranger during 2004, where the health of workers and members of the public may have been affected. One incident related to the exposure of some workers to contaminated drinking water (potable water contamination incident) and the other involved earth moving equipment with contaminated material leaving the mine site (radiation clearance incident).[82]

82 ACF, *op. cit.*, p. 20.

6.86 The GAC, ACF and others argued that such incidents are indicative of 'systematic underperformance and non compliance' by the company concerned, Energy Resources of Australia Ltd (ERA).[83] Mr Justin Tutty further alleged that the level of monitoring and compliance at Ranger is 'vastly unsatisfactory' and the CFMEU submitted that the union is concerned about negligence and health and safety practices at uranium mines more generally.[84]

6.87 The Australian Government Department of the Environment and Heritage (DEH) submitted that monitoring of radiation exposure to workers has shown that at Ranger dose levels have been generally decreasing with time and typical levels are less than 10 per cent of the statutory limit, with only three incidents of any note over the life of the mine. In 1982 a product packing incident created a dust hazard where the radiation dose may have exceeded the limit for one or both of the affected workers in the area. However, such exposure did not result in any detectable injury to either worker but elevated exposure levels are interpreted as possibly contributing to a statistical increase in lifetime risk of contracting cancer. During the water contamination incident in 2004 a number of Ranger workers were exposed to contaminated water through ingestion and/or showering. However investigations concluded that resultant radiological doses were below statutory limits.[85]

6.88 DEH further submitted that, generally, doses to members of the public have been very small, approaching the limits of detection of monitoring equipment. However, as noted above, in 2004 earthmoving equipment left the Ranger site without adequate radiation clearance checking, resulting in contamination of the workplace of a member of the public and exposure of that person and his children to radiation doses that were conservatively estimated to be at or near the statutory dose limit for members of the public. This incident was of concern from a regulatory perspective. However, DEH argued that the radiation doses received by members of the public did not represent a significant health risk.[86]

6.89 Mr Harry Kenyon-Slaney, Chief Executive of ERA, explained that while the accidents were unacceptable, they did not result in any negative impacts to human health:

> In both cases, it has been confirmed and accepted that there has been no impact on anybody's health as a consequence of those

83 *ibid*., p. 21; GAC, *op. cit*., p. 58.

84 Mr Justin Tutty, *op. cit*., pp. 5–6; CFMEU, *op. cit*., p. 2;

85 DEH, *Submission no. 55*, pp. 22–23.

86 *ibid*.

> incidents, but we took them extremely seriously. Frankly, they were unacceptable.[87]

6.90 The two incidents were investigated by the Supervising Scientist, the NT Department of Business, Industry and Resource Development and the mining company. The reports of the Supervising Scientist's investigations were tabled in the Senate on 30 August 2004. The Australian Government Minister for Industry, Tourism and Resources subsequently wrote to ERA requiring it to fulfil a series of conditions. Progress towards compliance with the conditions was assessed during audits by ANSTO and ARPANSA in September 2004, November 2004 and January 2005. Those audits have indicated satisfactory progress. ERA voluntarily shutdown operations following the tabling of the reports to allow it to focus on implementation of the Minister's requirements.[88]

6.91 The Supervising Scientist's *Annual Report 2004–2005* states that in March 2005 the Minister wrote to ERA to advise that, on the basis of the audit reports by ANSTO and ARPANSA, ERA had, with the exception of the implementation of the workplace safety standard AS4801, complied with all of the Minister's conditions.[89] ERA's *2005 Annual Report* states that in September 2005 the company achieved certification of its health and safety management system to AS4801.[90]

6.92 In relation to the audit findings and conditions to which ERA was asked to comply, Mr Kenyon-Slaney noted that:

> We went through a process of audits that were set up by the Commonwealth government after the reports by the Supervising Scientist were issued. It was a very comprehensive audit process, with which we were happy to comply and, by the end of last year, we had met all three of the audits that were set up by the Department of Industry, Tourism and Resources. As part of the audit process and as confirmation of a lot of work we were already doing, we put in place a whole series of new procedures and practices which strengthened our compliance with our water systems in the plant and the radiation clearance procedures. Those have been signed off and given a ringing endorsement by ARPANSA.[91]

87 Mr Harry Kenyon-Slaney (ERA), *Transcript of Evidence*, 24 October 2005, p. 53.

88 DEH, *loc. cit.*

89 Supervising Scientist, *Annual Report 2004–2005*, DEH, Darwin, 2005, pp. 34–35.

90 ERA, *2005 Annual Report*, ERA, Darwin, 2006, p. 13, viewed 26 September 2006, <http://www.energyres.com.au/corporate/era-ar-2005.pdf>.

91 Mr Harry Kenyon-Slaney, *loc. cit.*

Radiation exposure from the nuclear fuel cycle

6.93 Several submitters expressed intense opposition to the nuclear power industry on the basis of the risks to public health and the alleged health effects of the industry's operations, and particularly the claimed hereditary mutagenic and carcinogenic effects of nuclear materials. For example, Dr Helen Caldicott argued that the nuclear industry causes cancer and that exporting uranium is tantamount to 'exporting disease':

> The nuclear industry is about cancer. We are talking about nuclear waste that lasts for up to half a million years, which at the moment is seeping out of containers all over the United States … The incidence of cancer in those areas is increasing. You cannot cure cancer, generally—not adult cancer … That is the legacy that this industry will bequeath to all future generations, and we are not the only creatures that have genes. All creatures have genes, all creatures get cancer and all creatures get genetic disease … We inhabit the planet with 30 million other species … We should not be mining uranium, because what we are actually doing is exporting disease.[92]

6.94 As noted in the previous chapter, Dr Caldicott also submitted that:

> Nuclear reactors consistently release millions of curries of radioactive isotopes into the air and water each year. These releases are unregulated because the nuclear industry considers these particular radioactive elements to be biologically inconsequential. This is not so.[93]

6.95 The Uniting Church in Australia (Synod of Victoria and Tasmania) asserted that risks from nuclear power and the fuel cycle to workers and the public are 'too high' and that:

> Workers in nuclear facilities (including mines, mills and storage sites), and the public in close proximity to these facilities, are experiencing serious health problems such as cancers, leukaemia, and genetic defects.[94]

6.96 The MAPW (Victorian Branch) argued that nuclear power produces radioactive materials that require long time frames to lose their toxicity

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92 Dr Helen Caldicott, *op. cit.*, pp. 4–5.

93 Dr Helen Caldicott, *Exhibit no. 24, Nuclear power is the problem, not the solution*, p. 1.

94 Uniting Church in Australia (Synod of Victoria and Tasmania), *Submission no. 40*, p. 12.

and 'these are … simply materials that should not be added to the human environment where they can pose such a long-term risk.'[95]

6.97 Mr Justin Tutty, Dr Caldicott and others also claimed that routine releases of radioactive gases into the air and water from nuclear reactor operations, which were discussed in the previous chapter, pose an unsustainable burden on public health:

> … it must be recognised that nuclear power stations represent an unsustainable burden on both public health and the immediate environment due to the deliberate release of radiation into the skies and surrounding waters.[96]

6.98 In contrast, other submitters argued that the amount of radiation exposure to the public from uranium mines and the nuclear power industry as a whole is insignificant when compared to natural radiation exposure. For example, Dr Clarence Hardy of the Australian Nuclear Association (ANA) argued that:

> I would say that there is so much radiation coming from the sun—and from the whole universe, not just the sun … to the earth. There is a radiation field entering the earth. There is also basic radiation coming from the earth, from all of the radioactive materials in the earth. That amount of radiation on the earth is so significant that any tiny amount from the uranium industry is absolutely insignificant. You are getting all of this solar radiation … from the sun, plus all of the cosmic radiation and gamma radiation, as well as visible radiation. That flux on the earth is so enormous that the amount that any uranium mine or nuclear power plant is generating is totally insignificant. I do not think it is a factor to be taken into account at all.[97]

6.99 The MCA submitted that: 'It is recognised by government authorities that the major exposure to radiation for members of the public arises in the medical and dental sectors.'[98]

6.100 In a report to the UN General Assembly in 2000, UNSCEAR reviewed the worldwide doses from nuclear power production for the period of the mid 1990s. This followed similar studies conducted over previous assessment periods back to the early 1970s. Exposures were modelled for each stage of

95 Associate Professor Tilman Ruff (MAPW–Victorian Branch), *Transcript of Evidence*, 19 August 2005, p. 25.

96 Mr Justin Tutty, *Submission no. 41*, p. 5; Uniting Church in Australia (Synod of Victoria and Tasmania), *loc. cit.*; Dr Helen Caldicott, *Exhibit no. 24, Nuclear power is the problem, not a solution*, p. 2.

97 Dr Clarence Hardy (ANA), *Transcript of Evidence*, 16 September 2005, p. 59.

98 MCA, *loc. cit.*

the nuclear fuel cycle (including uranium mining and milling) and estimates of the doses were made for workers and for the public. The material below summarises the report's findings for exposures to employees and to the public from fuel cycle industries and their effluents.

Occupational exposures

6.101 UNSCEAR examined doses to workers at each stage of the nuclear fuel cycle and reported doses for the following categories of workers: uranium mining, uranium milling, uranium enrichment and conversion, fuel fabrication, reactor operations, fuel reprocessing, waste handling and disposal, and research and development activities associated with the nuclear fuel cycle.

6.102 There were 800 000 workers in the nuclear industry monitored in the most recent UNSCEAR study and the average doses received by these workers are listed in table 6.3. The total average annual effective dose to monitored workers was 1.75 mSv. This continued a downward trend evident in employee exposures reported by UNSCEAR in previous assessments. The total annual average effective dose to monitored workers in 1977–1979 was 4.1 mSv, in 1980–1984 it was 3.7 mSv, and in 1985–1989 it was 2.9 mSv.[99]

Table 6.3 Worldwide occupational exposures from nuclear power production (1990–1994)

Category	Number of workers	Average annual effective dose to monitored workers (mSv)
Uranium mining	69 000	4.5
Uranium milling	6 000	3.3
Uranium enrichment and conversion	13 000	0.12
Fuel fabrication	21 000	1.03
Reactor operation	530 000	1.4
Fuel reprocessing	45 000	1.5
Research in the fuel cycle	120 000	0.78
Total	*800 000*	*1.75*

Source ARPANSA, *Submission no. 32*, p. 19.

99 See: UNSCEAR, *Sources and Effects of Ionizing Radiation, Report to the UN General Assembly, 2000, Volume I, Annex E,* UNSCEAR, Vienna, 2000, p. 584, viewed 14 September 2006, <http://www.unscear.org/docs/reports/annexe.pdf>.

6.103 Among its findings, UNSCEAR noted that there had been a significant reduction in the doses to uranium mining and milling workers, with doses falling by a factor of three over the previous 20 years. These results follow a worldwide decline in underground mining activity and more efficient mining operations. Similarly, the dose to workers in reactor operations, which varies significantly for different types of reactors, had likewise fallen by a factor of three over the previous 20 years to 1.4 mSv in 1990–1994.[100]

6.104 UNSCEAR calculated the average annual doses to workers in various other occupations exposed to ionising radiation, which are listed in table 6.4. The occupations are classified by whether workers are exposed to artificial sources of radiation, which arise from human activities (e.g. the nuclear power industry and medical uses of radiation), or natural sources (e.g. aircrew in civil aviation and radon exposure in workplaces). The data shows that, as noted above, the average annual effective dose for those employed in nuclear power production is 1.75 mSv. However, the average dose to workers exposed to natural sources of radiation is slightly greater at 1.8 mSv and, of these, aircrew in civil aviation are exposed to an average 3.0 mSv (from cosmic radiation) and radon exposure in some above-ground workplaces is estimated to average 4.8 mSv.[101]

6.105 In the Australian context, the Committee's attention was drawn to the findings of a study of mortality rates among nuclear industry workers at ANSTO's Lucas Heights Science and Technology Centre, published in the Australian and New Zealand Journal of Public Health in June 2005. The project, which was part of an international study on nuclear industry workers from 14 countries undertaken by the International Agency for Research on Cancer, involved 7 076 workers employed at ANSTO's Lucas Heights facilities between 1957–1998. The project's objective was to assess whether the Lucas Heights workers have different levels of mortality from the NSW and Australian populations. It was found that all-cause mortality was 31 per cent lower than the national rates and all-cancer mortality was 19 per cent below the NSW rate. Of 37 specific cancers and groups of cancers examined, statistically significant excesses relative to NSW mortality rates were observed only for one type of cancer (pleural cancer, which is strongly related to asbestos exposure and unrelated to ionising radiation).[102]

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100 ARPANSA, *op. cit.*, p. 17.

101 UNSCEAR, *op. cit.*, p. 647.

102 Information provided by S Thorogood (ANSTO), 13 February 2006. ANSTO, *Media Release,* 'ANSTO Mortality Below National Level: Latest Report', 1 June 2005, viewed 22 September 2006, <http://www.ansto.gov.au/info/press/2005/anstomedia013_010605.pdf>.

Table 6.4 Worldwide occupational radiation exposures (1990–1994)

Source / practice	Average annual effective dose to monitored workers (mSv)
Artificial sources	
Nuclear fuel cycle (including uranium mining)	1.75
Industrial used of radiation	0.51
Defence activities	0.24
Medical uses of radiation	0.33
Education/veterinary	0.11
Total from artificial sources	*0.6*
Enhanced natural sources	
Air travel (aircrew)	3.0
Mining (other than coal)	2.7
Coal mining	0.7
Mineral processing	1.0
Above ground workplaces (radon)	4.8
Total from natural sources	*1.8*

Source UNSCEAR, *Sources and Effects of Ionizing Radiation, Report to the UN General Assembly*, *2000*, *Volume I*, p. 8.

6.106 ANSTO also notes that the average worker at Lucas Heights receives a dose of 1 mSv per year and those working in the most active areas receive less than 10 mSv, well below internationally accepted levels.[103]

Exposures to the public

6.107 The dose received by a whole population that is exposed to radiation is referred to as the 'collective effective dose' (or simply 'collective dose') and is calculated by adding the effective doses received by all of the people in the defined population. The unit of collective dose is the man Sievert (man Sv).[104] To evaluate the total impact of radionuclides released at each stage of the nuclear fuel cycle, UNSCEAR presents normalised collective effective doses per unit electrical energy generated, expressed as man Sv per gigawatt year $(GWa)^{-1}$.

6.108 The normalised collective doses to members of the public from radionuclides released in the various stages of the nuclear fuel cycle are

103 ANSTO, Media Release, *Largest Study of International Radiation Workers: Standards Meet the Mark*, 29 June 2005, viewed 22 September 2006, <http://www.ansto.gov.au/info/press/2005/anstomedia019_290605.pdf>.

104 IAEA, *op. cit.*, p. 12.

summarized in table 6.5. Doses to the public are divided into the local/regional component and a global component.

Table 6.5 Normalised collective effective dose to members of the public from radionuclides released in effluents from the nuclear fuel cycle (1995–1997)

Source	Normalised collective effective dose (man Sv(GWa)$^{-1}$)
Local and regional component	
Mining	0.19
Milling	0.008
Mine and mill tailings (releases over five years)	0.04
Fuel fabrication	0.003
Reactor operation Atmospheric Aquatic	 0.4 0.04
Reprocessing Atmospheric Aquatic	 0.04 0.09
Transportation	<0.1
Total (rounded)	*0.91*
Solid waste disposal and global component	
Mine and mill tailings (releases of radon over 10 000 years)	7.5
Reactor operations Low level waste disposal Intermediate level waste disposal	 0.00005 0.5
Reprocessing solid waste disposal	0.05
Globally dispersed radionuclides (truncated to 10 000 years)	40
Total (rounded)	*50*

Source UNSCEAR, *Sources and Effects of Ionizing Radiation, Report to the UN General Assembly, 2000, Volume I, Annex C*, p. 284.

6.109 The total local and regional collective dose in UNSCEAR's two most recent assessment periods is 0.9 man Sv (GWa)$^{-1}$. The largest part of this dose is received within a limited number of years after the releases and is mainly due to the normal operation of nuclear reactors and mining operations. The largest doses come from the continued use of some older reactors, with doses from modern Pressurised Water Reactors (PWR) about one fifth of those reported.[105]

105 UNSCEAR, *Sources and Effects of Ionizing Radiation, Report to the UN General Assembly, 2000, Volume I, Annex C,* UNSCEAR, Vienna, 2000, p. 190, viewed 15 September 2006, <http://www.unscear.org/docs/reports/annexc.pdf>; ARPANSA, *op. cit.*, p. 15.

6.110 The global dose, which is estimated for 10 000 years, amounts to 50 man Sv $(GWa)^{-1}$. After 100 years of nuclear power production, and assuming present generating capacity is maintained, the maximum annual *individual* dose to the global population would be less than 0.2 μSv (i.e. 0.0002 mSv, as listed in table 6.1). This dose combines both the local and regional component, and exposure to globally dispersed radionuclides. The dose is trivial in comparison to natural background radiation.[106]

6.111 According to UNSCEAR and submitted to the Committee by ARPANSA, the main contribution to the public dose is from globally dispersed carbon-14 (from reactor operations and reprocessing), due to its long half-life and the fact that it becomes part of the carbon cycle through the dispersion of carbon dioxide in the atmosphere.[107]

6.112 After carbon-14 emissions, the next largest contributor to the collective dose is attributable to radon emanating from uranium mine tailings. Tailings at uranium mines, which contain the long-lived radionuclides radium-226 and thorium-230, generate radon gas. The collective dose per unit energy produced is estimated to be 0.19 man Sv $(GWa)^{-1}$ during operation of the mine and the mill, and 7.5 man Sv $(GWa)^{-1}$ for an assumed 10 000 year period of constant, continued release from residual tailings piles.[108]

6.113 These estimates relate to mines operating in the mid 1990s and UNSCEAR notes that in an alternative study, site-specific data relating to currently operating mills in four countries (Australia, Canada, Namibia and Niger) were used. This study, which used a more detailed dispersion model than UNSCEAR and local and regional population densities applicable to the mines in question were much lower than those estimated by UNSCEAR, which take into account high population densities reported in areas surrounding mills in China. ARPANSA submitted that the tailings management practices employed at mines today are more rigorous than have been applied historically and soil covers to reduce radon emissions are more substantial than employed in the past. As a result, for currently-operating mines the alternative study found that the collective dose from radon emissions is five times lower at 1.4 man Sv $(GWa)^{-1}$ over a 10 000 year period. ARPANSA submitted that this value would be more representative of new and future mines operated in accordance with current international practice.[109]

106 UNSCEAR, *op. cit.*, pp. 190, 194.

107 ARPANSA, *loc. cit.*

108 *ibid.*, pp. 13, 20.

109 UNSCEAR, *op. cit.*, pp. 181–182.

6.114 UNSCEAR notes that the trends in collective doses per unit electrical energy generated show significant decreases since the 1970s, which is largely attributable to reductions in the release of radionuclides from reactors and fuel reprocessing plants. The components of normalized collective dose have decreased by more than an order of magnitude for releases from reprocessing plants, by a factor of seven for releases from reactors, and by a factor of two for globally dispersed radionuclides, compared to the earliest assessment period, 1970–1979.[110]

6.115 ARPANSA concluded that it is possible to estimate the future impact of nuclear power production for a PWR using uranium from a current uranium mine operating to international best practice. In this situation the contribution from mining and reactor operations would fall from 14 man Sv $(GWa)^{-1}$ to 7 man Sv $(GWa)^{-1}$. The overall effect of nuclear power production including fuel reprocessing would then be approximately 12 man Sv $(GWa)^{-1}$ in the hundredth year of practice. This would result in less than one additional fatal cancer from radiological exposures based on current risk factors. This would equate to an individual effective dose of approximately 0.3 µSv, or less than one thousandth of the dose received due to naturally occurring radionuclides.[111]

6.116 In sharp contrast, FOE made the allegation that some 80 000 fatal cancers will arise from the routine emissions from the nuclear fuel cycle.[112]

6.117 In response to the allegation that the emission of radioactive gasses from nuclear power plants is unregulated, ARPANSA noted that, internationally, regulatory agencies regulate in terms of the total dose to the public near to the facility and not necessarily by specific radionuclides, such as iodine-131. ARPANSA also argued that the discharge from Lucas Height exposes the people nearby to a trivial dose that is well below international best practice.[113]

6.118 Similarly, ANSTO stated that:

> If you stood on the boundary of Lucas Heights for 24 hours a day, 365 days a year and breathed it all in, you would get about the same dose as flying from Sydney to Melbourne … We have that data. It is measured data, and it has been around for years.
>
> The other issue—and the reason she [Dr Caldicott] makes that claim—is that nuclear power plants do not produce iodine because

110 *ibid*., p. 190.

111 ARPANSA, *op. cit*., p. 20.

112 FOE et. al., *Exhibit no. 71, Nuclear Power: No Solution to Climate Change*, section 5.2 Comparing alternative energy sources.

113 Dr John Loy, *op. cit*., pp. 73–74.

> they do not produce radioisotopes for medicine, and iodine is one of those. So it is a spurious type of argument. The key issue is: what dose might people receive? The whole concept of radiation protection takes into account where it comes from, and you can compare it dose for dose—and dose for dose Lucas Heights produces almost nothing.[114]

Nuclear safety

6.119 Some submitters pointed to alleged hazards of current nuclear reactors, evolutionary reactor designs and future reactor concepts. For example, the ACF pointed to a report commissioned by Greenpeace which asserted, inter alia, that:

- all operational reactors have very serious inherent safety flaws which cannot be eliminated by safety upgrading;
- a major accident in a light-water reactor could lead to catastrophic radioactive releases;
- new reactor lines are envisaged which are heralded as fundamentally safe. However, apart from having their own specific safety problems, those new reactors would require enormous sums for their development;
- life extensions to reactors leads to the degradation of critical components and the increase of 'severe' incidents;
- de-regulation of electricity markets has pushed nuclear utilities to decrease safety-related investments and limit staff; and
- reactors cannot be sufficiently protected against a terrorist threat.[115]

6.120 Mr Justin Tutty also alleged that the risk of catastrophic radioactive releases is an unavoidable feature of nuclear power generation.[116] Similarly, the Arid Lands Environment Centre (ALEC) argued that: 'The spectre of catastrophic failure still looms large' and there are hazards at all steps of the nuclear energy chain, particularly in reactors and reprocessing plants.[117] Likewise, Mr John Klepetko alleged that:

114 Dr Ron Cameron (ANSTO), *Transcript of Evidence*, 13 October 2005, p. 16.

115 ACF, *op. cit.*, p. 15.

116 Mr Justin Tutty, *op. cit.*, p. 5.

117 ALEC, *Submission no. 75*, p. 3.

> The history of uranium's role in serious accidents and long lasting legacies of these accidents are a stark reminder of why widespread uranium use should not be pursued in the future.[118]

6.121 Mr David Addison argued that the potential damage a nuclear accident could cause is high enough in consequence for the burden of proof to be on those who promote nuclear energy to prove its safety:

> I appreciate that safety technology and procedures supportive [of] nuclear energy has most likely improved over the last decade. At the same time I still believe that the potential damage of a nuclear accident and the release of radioactive materials are high enough in consequence for the burden of proof to be on those who advance nuclear energy as a solution to our energy requirements, rather than on those who oppose.[119]

6.122 MAPW (WA Branch) specifically pointed to the risks of reactors being built in Indonesia and the possibility of accidents 'with the prospect of the fallout from any meltdown being carried by the prevailing winds … towards Australia.'[120]

Reactor safety

6.123 In response to these concerns, other submitters emphasised that the risks from western nuclear power plants, in terms of the consequences of an accident or terrorist attack, are minimal compared with other commonly accepted risks.[121]

6.124 It was argued that nuclear power has proven to be an extremely safe form of power generation. In the 50-year history of civil nuclear power generation, which spans more than 12 000 cumulative reactor years of commercial operation in 32 countries, there have been two significant accidents to nuclear power plants:

- Three Mile Island (TMI) in the US in 1979, where the reactor was severely damaged but the plant design contained the radiation and there were no adverse health and environmental consequences; and

118 Mr John Klepetko, *Submission no. 86*, p. 1.

119 Mr David Addison, *Submission no. 59*, p. 1.

120 Dr Peter Masters (MAPW – WA Branch), *Transcript of Evidence*, 23 September 2005, p. 36.

121 UIC, *Safety of Nuclear Power Reactors*, Nuclear Issues Briefing Paper No. 14, viewed 19 September 2006, <http://www.uic.com.au/nip14.htm>.

- Chernobyl in Ukraine in 1986, where the destruction of the reactor by explosion and fire killed 31 workers, with the death toll subsequently rising to about 56.[122]

6.125 While there have been other incidents at nuclear reactors, the Chernobyl accident, which is discussed further below, is the only accident at a commercial nuclear power plant that has resulted in fatalities. Furthermore, Chernobyl is said to be the only accident where radiation doses to the public were greater than those resulting from exposure to natural sources. Other incidents have been completely confined to the plants involved.

6.126 AMP Capital Investors Sustainable Funds Team (AMP CISFT), who oppose the use of nuclear power, observed that:

> The modern engineering design of nuclear reactors are designed to represent a very low risk to the public and therefore to date there has only been one major nuclear accident that led to death of [members of] the public.[123]

6.127 Areva submitted that safety at nuclear reactors is realised in the form of precautionary measures in design, construction and operation. Nuclear plants operate using a three-level 'defence in depth' concept: first, to prevent any accident; second, to monitor and protect safety; and third, to avoid unacceptable consequences.

6.128 In turn, safe reactor design relies on a 'three barrier principle', involving series of strong, leak-tight physical 'barriers' which form a shield against radiation and confine radioactivity in all circumstances:

- the metal cladding of the fuel rods;
- the metal enclosure of the reactor primary circuit; and
- the containment surrounding the reactor.[124]

6.129 The UIC further explains that these barriers in a typical plant are: the fuel is in the form of solid ceramic pellets, and radioactive fission products remain bound inside these pellets as the fuel is burned. The pellets are packed inside sealed zirconium alloy tubes to form fuel rods. These are confined inside a large steel pressure vessel with walls up to 30 cm thick, with the associated primary water cooling pipework also substantial. All

122 Nuclear incidents and accidents are classified according to an International Nuclear Event Scale (INES) developed by the IAEA and OECD in 1990. The scale runs from a zero event with no safety significance to a seven for a 'major accident' such as Chernobyl. TMI rated five, as an 'accident with off-site risks'.

123 AMP CISFT, *Submission no. 60*, p. 6.

124 Areva, *Submission no. 39*, p. 6.

this, in turn, is enclosed inside a reinforced concrete containment structure with walls at least one metre thick.

6.130 However, the UIC comments that the main safety features of most reactors are inherent—'negative temperature coefficient' and 'negative void coefficient'. The first means that beyond an optimal level, as the temperature increases the efficiency of the reaction decreases (this is used to control power levels in some new designs). The second means that if any steam has formed in the cooling water there is a decrease in moderating effect so that fewer neutrons are able to cause fission and the reaction slows down automatically.[125]

6.131 Beyond the control rods which are inserted to absorb neutrons and regulate the fission process, the main engineered safety provisions are the back-up emergency core cooling system (ECCS) to remove excess heat (though this is more to prevent damage to the plant than for public safety) and the containment structure.

6.132 The basis of design assumes a threat where, due to accident or malign intent (e.g. terrorism), there is core melting and a breach of containment. Nuclear power plants are also designed with sensors to shut them down automatically in an earthquake, as this is a vital consideration in many parts of the world (e.g. Japan).

6.133 Professor Leslie Kemeny submitted that nuclear reactors are highly robust:

> Fear of nuclear-risks is usually focused on accidental releases of nuclear radiation. Potentially, this can occur in incidents ranging from terrorist acts or geological instability to plant failure and human operator mistake. Nuclear plants are, however, incredibly robust: Japan's 54 nuclear power stations withstand earth tremors and will automatically shut down at the onset of a major quake.
>
> Reinforced concrete reactor containment domes are designed to withstand the impact of crashing aircraft …[126]

6.134 Investigations following the TMI accident led to a new focus on the human factors in nuclear safety. According to the UIC, no major design changes were called for in western reactors, but controls and instrumentation were improved and operator training was overhauled. In contrast, the Chernobyl reactor did not have a containment structure like those used in the West or in post-1980 Soviet designs.

6.135 One mandated safety indicator for reactors is the probable frequency of degraded core or core melt accidents. The US Nuclear Regulatory Commission (NRC) specifies that reactor designs must meet a 1 in 10 000

125 UIC, *Safety of Nuclear Power Reactors, loc. cit.*

126 Professor Leslie Kemeny, *Exhibit no. 9, op. cit.*, p. 2.

year core damage frequency, but modern designs are said to exceed this. US utility requirements are 1 in 100 000 years, the best currently operating plants are about 1 in one million years and those likely to be built in the next decade are almost 1 in 10 million years. Regulatory requirements are that the effects of any core-melt accident must be confined to the plant itself, without the need to evacuate nearby residents.[127]

6.136 The UIC notes that the main safety concern has always been the possibility of an uncontrolled release of radioactive material, leading to contamination and consequent radiation exposure off site. It has been assumed that this would follow a major loss of cooling accident (LOCA) which resulted in a core melt. However, UIC argued that experience has proved otherwise in any circumstances relevant to Western reactor designs. Studies of material in a reactor core under extreme conditions, including the post-accident situation at TMI, have found that a severe core melt coupled with a breach of containment could not in fact create a major radiological disaster from any Western reactor design.[128]

6.137 Areva noted that some 12 000 reactor years of operation has contributed greatly to global experience in reactor design. This experience and extensive research and development programs are said to have had a significant impact, improving plant performance and enhancing safety.[129] ANSTO and others also emphasised technological developments in reactor and fuel cycle design which are focused on enhanced safety.

6.138 Mr Jerry Grandey, Chief Executive Officer of Cameco Corporation, explained that in Western Europe and the US a new generation of reactors are now being certified by regulatory agencies that are 'passively safe'; that is, they use gravity instead of depending on mechanical devices for the operation of safety features. Mr Grandey observed that, like any other industry, the nuclear power industry is continually striving to develop improved technology. Improved plants are already being deployed in some countries, such as Japan, Finland, France and China.[130]

6.139 Several generations of reactors are commonly distinguished. Generation I reactors were developed in the 1950–60s and outside the UK none are still operating today. Generation II reactors are typified by the present US fleet and most in operation elsewhere. Generation III (and III+) designs are known as 'Advanced Reactors' and are now being deployed, with the first in operation in Japan since 1996 and one each being built in France and Finland. Generation IV designs are still being developed, with some at an

127 UIC, *Safety of Nuclear Power Reactors*, *loc. cit*.

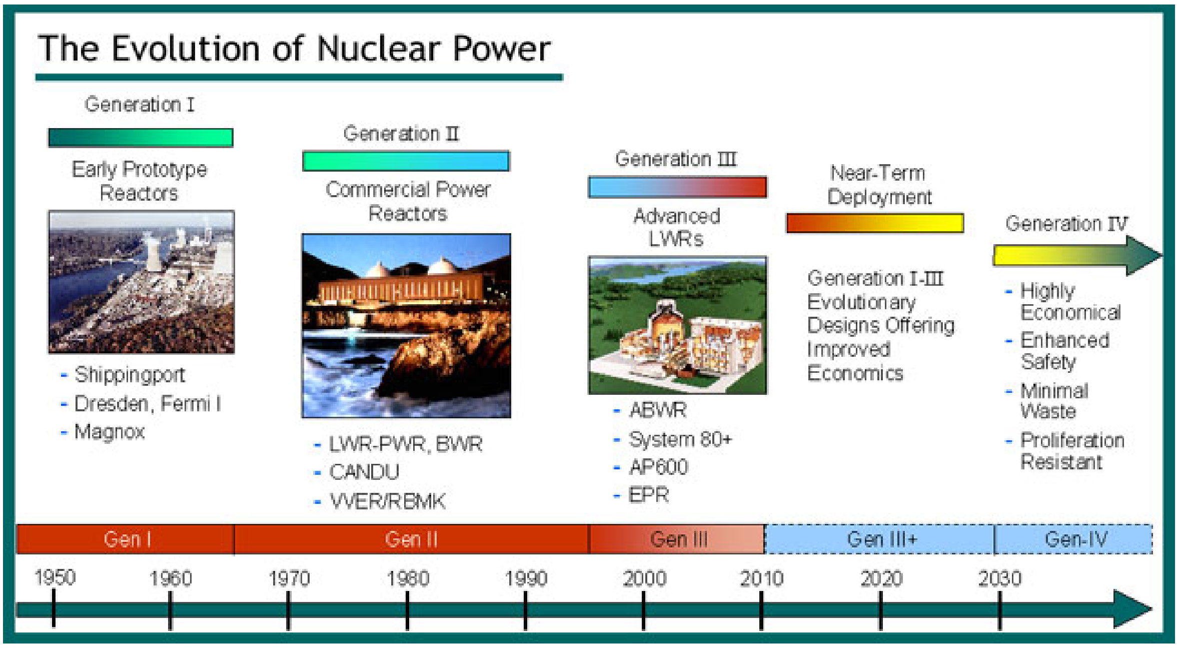
128 *ibid*.

129 Areva, *loc. cit*.

130 Mr Jerry Grandey (Cameco Corporation), *Transcript of Evidence*, 11 August 2005, p. 11.

advanced stage (such as the Modular Helium Reactor, mentioned in the previous chapter, which is now in advanced development by General Atomics in the US), and will not be operational before 2020 at the earliest.[131] Figure 6.1 depicts the evolution of nuclear reactor designs.

Figure 6.1 The evolution of nuclear reactor designs



Source US Department of Energy, *Generation IV Nuclear Energy Systems.*

6.140 The UIC explains that the most significant departure from second-generation designs is that many Advanced Reactors incorporate passive or inherent safety features which require no active controls or operational intervention to avoid accidents in the event of malfunction, and may rely on gravity, natural convection or resistance to high temperatures.[132] It is argued that these reactors are one or two orders of magnitude safer than second generation reactors in respect to the likelihood of core melt accidents.

6.141 Examples of third-generation reactors in the US include the advanced boiling water reactor (ABWR) derived from a General Electric design, which the NRC notes exceeds NRC safety goals by several orders of magnitude, and the Westinghouse AP-600 (AP = Advanced Passive). Both designs have been granted NRC design certification. The AP-600s

131 ANSTO, *Exhibit no. 74, Presentation by Dr Ron Cameron and Dr Ian Smith*, slide no. 46.

132 Traditional reactor safety systems are 'active' in the sense that they involve electrical or mechanical operation on command. Some engineered systems operate passively, eg pressure relief valves. Both require parallel redundant systems. Inherent or full passive safety depends only on physical phenomena such as convection, gravity or resistance to high temperatures, not on functioning of engineered components.

projected core damage frequency is nearly 1 000 times less than today's NRC requirements.[133]

6.142 One of four Advanced Reactor designs currently being developed to meet European utility requirements is the European pressurised water reactor (EPR) proposed by Areva, which is an example of a Generation III+ design. The first EPR is currently being built in Finland and a second is to be built in France. Areva noted that key design improvements are the total confinement of radioactivity even in the most serious accident scenarios and reinforced protection against external events. The reactor's safety systems have been simplified, diversified, more fully automated and a greater degree of redundancy has been incorporated.

6.143 Areva submitted that the EPR has several novel safety features and the design meets demands expressed by European electricity companies and safety authorities:

- according to safety margins compared with the other French reactors, the EPR has a ten times lower probability of a major accident (e.g. to provide emergency cooling of the reactor core, four independent sub-systems have been introduced);
- even in case of a severe accident with a core melt and piercing of the reactor vessel, leak tight containment ensures no external radioactive release and no consequence on neighbouring population;
- also in case of severe accident and core bleed through the vessel bottom, a special 'ash-tray' underneath would recover the melted material, preventing any radioactive intrusion underground (the containment building stands on a concrete base mat 6 m thick); and
- protection against external events (including fire, flood and falling aircraft) has been reinforced, including independent redundant systems to prevent common failure and a double containment of two 1.3 m thick walls (giving a total of 2.6 m of concrete).[134]

6.144 Beyond third-generation reactors, two international initiatives have been launched to define future reactor and fuel cycle technology. The Generation IV International Forum (GIF) is a US-led grouping of twelve countries established in 2001, which has identified six reactor concepts for further investigation with a view to commercial deployment between 2010 and 2030. The six systems are intended to offer increased safety, improved economics for electricity production and new products such as hydrogen

133 See also: UIC, *Advanced Nuclear Power Reactors*, Nuclear Issues Briefing Paper No. 16, August 2006, viewed 20 September 2006, <http://www.uic.com.au/nip16.htm>.

134 Areva, *op. cit.*, p. 7. See also: Areva, *EPR: A reactor for maximum safety*, viewed 20 September 2006, <http://www.areva-np.com/>.

for transportation applications, reduced nuclear wastes for disposal, and increased proliferation resistance.[135]

6.145 The other initiative is the IAEA's International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO), which has some 21 members and is focused more on developing country needs, and initially involved Russia rather than the US, though the US has now joined the Project. INPRO is intended to complement the GIF in promoting innovative concepts.[136]

6.146 Some of the Generation IV reactor designs will be inherently safe by virtue of being immune from the possibility of core melt accidents and passively safe. Among these designs are the very high-temperature gas reactors (one of the six GIF concepts), which includes pebble bed modular reactors (PBMR) under development in South Africa and China, and the gas turbine-modular helium reactor (GT-MHR) being developed by General Atomics. Among their other characteristics, these designs can accommodate the total loss of coolant without the possibility of a meltdown. The reactors' negative temperature coefficient inherently shuts down the core when it rises above normal operating temperatures. Furthermore, the helium (in which the core is bathed) which is used to transfer heat from the core to the turbines is chemically inert. It cannot combine with other chemicals and is non-combustible. Being passively safe, in the case of emergency no human intervention would be required in the short or medium term in these reactors.[137]

6.147 Silex Systems also argued that safety has been a top priority for the industry since reactors were first deployed commercially and that the current reactor fleet has been made safer by modifications over time. Third generation reactors, which are now being deployed, include inherent safety features and fourth generation designs, such as the PBMR and GT-MHR designs mentioned above, ensure that an event in the reactor core cannot even occur:

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135 Dr Ron Cameron (ANSTO), *Transcript of Evidence*, 13 October 2005, p. 11. See also: US Department of Energy, *Generation IV Nuclear Energy Systems*, viewed 20 September 2006, <http://gen-iv.ne.doe.gov/documents/geni.pdf>; Generation IV International Forum, *Fact Sheet*, viewed 20 September 2006, <http://www.gen-4.org/GIF/About/factsheet.htm>.

136 See: IAEA, *INPRO Status 2005*, viewed 20 September 2006, <http://www.iaea.org/OurWork/ST/NE/NENP/NPTDS/Downloads/Brochure/2005_INPRO_Brochure.pdf>.

137 Nova Energy Ltd, *Submission no. 50*, p. 14. See: MP LaBar, *The Gas Turbine – Modular Helium Reactor: A Promising Option for Near Term Deployment*, General Atomics, San Diego USA, 2002, pp. 7–8, viewed 20 September 2006, <http://gt-mhr.ga.com/2hieff_all.html>; Pebble Bed Modular Reactor Pty Ltd, *How safe is PBMR?*, viewed 20 September 2006, <http://www.pbmr.com/index.asp?content=5>.

> The industry has made risk analysis a complete science from which many other industries have benefited. The current fleet of nuclear reactors has been improved steadily and is now operating very reliably and efficiently. There is no long-term safety issue with the current fleet.
>
> Third and fourth generation reactors are being developed. Some third generation reactors have already been built in Japan. These reactors have process-inherent safety features. If the reactor core has an excursion—if it misbehaves—automatically the reactor goes into a failsafe mode, natural forces take over and human intervention is cut out …
>
> Fourth generation reactors, which are being developed now—they have not been commercially deployed—go one step further. They are built so that inherently the fuel is configured so that an excursion—an event of misbehaviour in the reactor—cannot even occur in the first place. They shut down before the excursion manifests. Examples are the pebble bed reactor being developed in China and South Africa with some German interests, and the modular high temperature gas cooled reactor being developed by General Atomics in the USA. These reactors will become the future reactor of choice. Reactor safety, I believe, is now not a technical issue. There is a public perception issue, and the industry has to educate the public and governments alike.[138]

6.148 Nova Energy also argued that new and advanced reactor designs are now far safer than those that operated in previous decades:

> There is an acceptance that the new generation of reactors, of which pebble bed reactors are one, are considered safer, cheaper to build and environmentally a better option. The point we are trying to make is that the technology in terms of nuclear reactor development and nuclear power stations has advanced significantly over the last 20 to 30 years. That is often not recognised in the discussion about concerns around nuclear power and nuclear energy, which often go back to views based on 1970s technology.[139]

6.149 Areva commented that public perceptions of reactor designs are still shaped by the Chernobyl accident and fail to appreciate the technical developments that have occurred since:

138 Dr Michael Goldsworthy (Silex Systems Ltd), *Transcript of Evidence*, 9 February 2006, p. 4.
139 Mr Richard Pearce (Nova Energy Ltd), *Transcript of Evidence*, 23 September 2005, p. 71.

> Most of the public see reactor designs as being similar to the Chernobyl design and having the same problems … the designs are dramatically different now. Even the Chernobyl design, as has been commonly stated, would never have been built in the Western world. The technology was far greater in the Western world than what it was in Chernobyl at the time that it was built. We have moved on. Last year [Areva] spent €402 million on research and development. The company spends a lot of money continuously, year after year. Many other companies are also doing that and trying to improve the technology and to improve the safeguards.[140]

6.150 AMEC also argued that, as with developments in the design of ships or aircraft, the evolution of reactor technologies needs to be acknowledged:

> If I can give you an analogy, in 1912 the *Titanic* sank. What did we do? We did not say we were never going to build another ocean liner; we said we were going to have to build them better and safer. We have been saying since 1986 that we have decided we are not going to close down all nuclear reactors; we are going to build better and safer ones. In the same way, we have the situation with the hurricanes in the United States. We have not said we are going to close down New Orleans because of hurricanes; we are going to try and build a better New Orleans.[141]

6.151 Similarly, the Committee notes the observation by Dr Patrick Moore, co-founder of Greenpeace, that:

> Accidents do happen in newly emerging technologies, and nuclear is no exception, but it is one of the safer newly emerging technologies that we have in the world.
>
> The fact is over 5 000 people die every year in coal mines around this world. If you look at automobiles, 1.2 million people die in automobile accidents every year. Who's banning the automobile?
>
> I mean, if you really wanted to ban a technology that was causing death and destruction and injury, it would be the car.[142]

6.152 Notwithstanding technological advances, the AMP CISFT was not confident that passive or inherent safety features incorporated into modern reactor designs could adequately mitigate against the risk of accidents.[143] Pointing to a 'near miss' incident at the Davis-Besse plant in

140 Mr Stephen Mann (Areva), *Transcript of Evidence*, 23 September 2005, p. 10.

141 Mr Alan Layton (AMEC), *Transcript of Evidence*, 23 September 2005, p. 15.

142 Dr Patrick Moore, 'Greenpeace co-founder welcomes nuclear debate', *AM*, ABC Radio, 8 June 2006, transcript of interview with David Weber.

143 Dr Ian Woods (AMP CISFT), *Transcript of Evidence*, 16 September 2005, p. 30.

the US, and incidents at reprocessing plants in the US and UK, AMP CISFT asserted that 'good engineering' is not enough to ensure safety:

> … good engineering design is not sufficient to ensure appropriate control of nuclear facilities and … human factors and errors are key underlying causes of accidents and incidents. Improvements in employee training, maintenance and record keeping of all parts of the nuclear value chain, the independent verification of these systems and improved regulatory control, are all required to a level well beyond that which is required by existing safeguards.[144]

6.153 It was argued that strict adherence to maintenance and safety rules on the part of nuclear workers are critical in providing the required level of health and safety assurance. However, AMP CISFT argued that incidents at reactors, reprocessing plants and uranium mines 'cast doubt over whether it is possible for … companies to address health and safety concerns and ensure that systems and procedures will be followed or are adequate.'[145]

6.154 MAPW (Victorian Branch) argued that incidents at TMI, Tokai-mura in Japan and Davis-Besse in the US shows that risks of serious accidents are not confined to specific types of reactors or to particular countries.[146]

Global nuclear safety regime

6.155 The IAEA states that a global nuclear safety regime exists which is comprised of four elements:

- the widespread subscription to binding and non-binding international legal instruments such as safety conventions and codes of conduct;
- a comprehensive suite of nuclear safety standards that embody good practices as a reference point to the high level of safety required for all nuclear activities;
- a suite of international safety reviews and services, based on the safety standards; and
- the need to ensure strong national infrastructures and a global experts' community.[147]

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144 AMP CISFT, *Submission no. 60*, p. 6.

145 AMP CISFT, *Exhibit no. 65, The Nuclear Fuel Cycle Position Paper*, p. 16; Dr Ian Woods, *op. cit.*, p. 28.

146 MAPW (Victorian Branch), *op. cit.*, p. 12.

147 IAEA, *Nuclear Safety Review for the Year 2005,* IAEA, Vienna, 2005, p. 2, viewed 21 September 2006, <http://www.iaea.org/About/Policy/GC/GC50/GC50InfDocuments/English/gc50inf-2_en.pdf>.

6.156 The principal international legal instruments include the:

- *Convention on Nuclear Safety*;
- *Convention on Early Notification of a Nuclear Accident*;
- *Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency*;
- *Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management*; and
- *Convention on the Physical Protection of Nuclear Material*.[148]

6.157 The IAEA has also developed Codes of Conduct relating to research reactors and on the safety and security of radioactive sources. The IAEA is also charged with developing Safety Standards which embody best practice and serve as guides for national regulatory rules and guidelines.

6.158 In addition to the application of safety standards, international peer review is also said to bring broader expertise, perspective and transparency to national safety assessment and verification processes and ultimately to improve public confidence. The IAEA conducts safety and security peer reviews and safety appraisals upon Member State request, including Operational Safety Review Team (OSART) and Peer Review of Operational Safety Performance Experience (PROSPER) missions. In 2005 the Agency conducted some 120 safety review missions covering topics including nuclear power plant operational safety, radiation source safety and security, nuclear and radiation safety infrastructure, and transport safety.[149]

6.159 The IAEA states that a key to promoting safety culture is the exchange of knowledge. To this end, the IAEA is promoting and facilitating the establishment of regional nuclear and radiation safety networks, such as the Asian Nuclear Safety Network. The IAEA also seeks to preserve and maintain knowledge through an International Nuclear Information System.[150] Areva also noted that the IAEA and the OECD Nuclear Energy Agency (OECD-NEA) jointly manage an international Incident Reporting System (INS), which has been established to facilitate the exchange of experience for the purpose of improving the safety of nuclear power plants.[151]

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148 See: IAEA, *Nuclear Safety Review for the Year 2004,* IAEA, Vienna, 2004, p. 3, viewed 22 September 2006, <http://www.iaea.org/Publications/Reports/nsr2004.pdf>.

149 For an overview of the IAEA's activities in relation to nuclear safety and security in 2005 see: IAEA, *IAEA Annual report 2005*, viewed 22 September 2006, <http://www.iaea.org/Publications/Reports/Anrep2005/>.

150 IAEA, *Nuclear Safety Review for the Year 2004, op. cit.*, p. 6.

151 Areva, *op. cit.*, p. 6.

6.160 There are also a number of forums in which national regulators can exchange information and experience with their counterparts in other countries, such as the International Nuclear Regulators Association and the Network of Regulators of Countries with Small Nuclear Programs.[152]

6.161 In addition to these international activities, peer review and knowledge exchange is also undertaken by other organisations, such as the World Association of Nuclear Operators (WANO) which was formed in 1989. WANO, whose membership includes every organisation in the world that operates a nuclear power plant, was established following the Chernobyl accident specifically to improve safety at every nuclear power plant in the world. WANO seeks to achieve its mission of maximising the safety and reliability of the operation of nuclear plants by exchanging information and encouraging communication, comparison and emulation amongst its members. It conducts activities including peer reviews, technical support and exchange, and professional and technical development. WANO has also developed a series of performance indicators for plant safety and reliability which are now reported by practically all operating nuclear power plants worldwide.[153]

6.162 Among its other findings, the IAEA's *Nuclear Safety Review for the Year 2005,* which reports on worldwide efforts to strengthen nuclear, radiation, transport and radioactive waste safety, concluded that:

> Nuclear power plant (NPP) operational safety performance … remained high throughout the world in 2005. Radiation doses to workers and members of the public due to NPP operation are well below regulatory limits. Personal injury accidents and incidents are among the lowest in industry. There have been no accidents that have resulted in the unplanned release of radiation that could adversely impact the environment. This operational safety performance is a strong testimony to the attention to improving the engineering and human performance attributes of safety that have occurred over the past two decades.[154]

6.163 The IAEA noted, however, that there is a need to guard against complacency by the industry and regulatory authorities, particularly in relation to operational safety performance, and that a continuing challenge is to collect, analyse and disseminate safety experience and knowledge.[155]

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152 IAEA, *Nuclear Safety Review for the Year 2005, op. cit.,* p. 3.

153 See: WANO, *What is WANO?*, viewed 21 September 2006, <http://www.wano.org.uk/WANO_Documents/What_is_Wano.asp>; Areva, *loc. cit.*

154 IAEA, *Nuclear Safety Review for the Year 2005, op. cit*., p. 5.

155 *ibid*., pp. i, 6.

In relation to the transport of radioactive material, the report found that the industry's good safety record continued in 2005.[156]

6.164 In a similar vein, the OECD-NEA's 2005 edition of *The Safety of the Nuclear Fuel Cycle* report reached the general conclusion that while more should always be done to enhance nuclear safety, for example in relation to human factors, nonetheless 'the fuel cycle industry has now reached a full maturity status and … nuclear safety is adequately mastered.'[157]

The Chernobyl accident

6.165 The Chernobyl accident occurred on 26 April 1986 at Unit 4 of the Chernobyl nuclear power plant in the former Ukrainian republic of the Soviet Union.

6.166 According to the US Nuclear Energy Institute (NEI), the four chernobyl reactors were PWRs of the Soviet RBMK design, which were intended to produce electrical power and plutonium. These reactors were said to be very different from standard commercial designs, employing a combination of graphite moderator and water coolant. The reactors were also highly unstable at low power, primarily owing to control rod design and a large positive void coefficient—factors that accelerated nuclear chain reaction and power output if the reactors lost cooling water.[158]

6.167 On the morning of 26 April 1986 the reactor crew at Chernobyl-4 began to prepare for a test involving a shut-down of the reactor (in order to determine how long turbines would spin and supply power following a loss of main electrical power supply). A series of operator actions, including the disabling of automatic shutdown mechanisms, preceded the attempted test. As the flow of coolant diminished, power output increased. When the operator sought to shut down the reactor from its unstable condition arising from previous errors, a peculiarity of the design caused a dramatic power surge.

6.168 The power surge caused a sudden increase in heat which ruptured some of the fuel elements. The hot fuel particles reacted with the water and caused a steam explosion which lifted off the cover plate of the reactor and released fission products to the atmosphere. The explosion ruptured the remaining fuel elements which caused a second explosion and exposed the reactor core to the environment. The second explosion threw out fragments of burning fuel and graphite from the core and allowed air to rush in, causing the graphite moderator to burst into flames. The graphite

156 *ibid*., p. 20.

157 OECD-NEA, *The Safety of the Nuclear Fuel Cycle*, OECD-NEA, Paris, 2005, pp. 300, 18.

158 NEI, *The Chernobyl Accident and Its Consequences*, NEI, Washington DC, April 2006, viewed 25 September 2006, <http://www.nei.org/doc.asp?catnum=3&catid=296>.

burned for the following nine days, causing the main release of radioactivity.[159]

6.169 The Chernobyl plant did not have a containment structure common to most nuclear power plants elsewhere in the world. Without this protection, radioactive material escaped into the environment. The explosions which ruptured the reactor vessel and the consequent fire resulted in large amounts of radioactive materials being released. The cloud from the burning reactor spreading numerous types of radioactive materials, especially iodine-131 (which has a half-life of eight days) and caesium-137 (which has a half-life of 30 years) over much of Europe. However, the greatest deposits of radionuclides occurred over large areas of the former Soviet Union, notably Belarus, the Russian Federation and Ukraine.[160]

6.170 In short, the UIC submitted that the Chernobyl accident resulted from a flawed Soviet reactor design that was operated with inadequately trained personnel and without proper regard for safety. The accident has led to a profound change in operational culture in the former Soviet Union.[161]

6.171 It was repeatedly emphasised that the Chernobyl plant would *never* have been certified for operation under regulatory regimes of western countries, due to reactor design shortcomings and the lack of safeguards. The UIC stated that all of the 13 remaining Soviet-designed RBMK reactors, identical to the Chernobyl reactor, have now been substantially modified, making them more stable and adding safety features like faster automatic shut-down mechanisms.[162]

6.172 Evidence presented to the Committee on the number of immediate fatalities caused by the accident and the possible number of eventual fatalities due to radiation exposure was strongly divided.

6.173 The MAPW (Victorian Branch) claimed in its submission that ‘at least 6 000 deaths resulted’ from the accident.[163] Dr Helen Caldicott claimed that, of the clean up workers alone, ‘5 000 to 10 000 are known to have died so far.’[164] Dr Caldicott also cited claims that the eventual number of fatal cancers caused by the accident will be between 140 000 and 450 000,

159 UIC, *Chernobyl Accident*, Nuclear Issues Briefing Paper No. 22, viewed 25 September 2006, <http://www.uic.com.au/nip22.htm>.

160 The Chernobyl Forum: 2003–2005, *Chernobyl’s Legacy: Health, Environmental and Socio-economic Impacts* (Summary Report), IAEA, Vienna, 2006, p. 10, viewed 25 September 2006, <http://www.iaea.org/Publications/Booklets/Chernobyl/chernobyl.pdf>.

161 UIC, *Submission no. 12*, p. 12.

162 *ibid*.

163 MAPW (Victorian Branch), *Submission no. 30*, p. 12.

164 Dr Helen Caldicott, *Exhibit no. 25, Nuclear Madness*, p. 134.

with an equal number of non-fatal cancers. That is, there will ultimately be almost one million cases of cancer attributable to the Chernobyl accident.[165] The FOE estimated that there will be 24 000 fatal cancers attributable to the accident.[166]

6.174 In September 2005 a major multi-agency UN report was released, *Chernobyl's Legacy: Health, Environmental and Socio-Economic Impacts*, which represents the most comprehensive evaluation of the Chernobyl accident's consequences to date. The report was produced by the Chernobyl Forum, which is comprised of eight agencies—IAEA, WHO, UNSCEAR, United Nations Development Program, Food and Agriculture Organisation, United Nations Environment Program, United Nations Office for the Coordination of Humanitarian Affairs, the World Bank and the governments of Belarus, the Russian Federation and Ukraine. The report, which involved the contributions of some 100 recognised international experts, represents a consensus view of the eight UN organisations and the three governments.

6.175 In relation to cancer mortality due to radiation exposure from the accident, the Chernobyl Forum states that claims that tens or even hundreds of thousands of persons have died as a result of the accident are 'highly exaggerated.'[167]

6.176 The report states that it is impossible to assess reliably, with any precision, the latent cancer deaths that may be caused by radiation exposure due to the accident. Further, radiation-induced cancers are at present indistinguishable from those due to other causes. The WHO notes that that number of such deaths can only be estimated statistically using information and projections from the studies of atomic bomb survivors and other highly exposed populations. However, the atomic bomb survivors received high radiation doses in a short time period (i.e. high dose rates), while Chernobyl caused low doses over a long time. This and other factors, such as trying to estimate doses people received some time after the accident, as well as differences in lifestyle and nutrition, cause very large uncertainties when making projections about future cancer deaths. In addition, a significant non-radiation related reduction in the average lifespan in the three countries over the past 15 years caused by overuse of alcohol and tobacco, and reduced health care, have significantly increased the difficulties in detecting any effect of radiation on cancer mortality.

165 *ibid.*, p. 135.

166 FOE, *Exhibit no. 71, Nuclear Power: No Solution to Climate Change*, Section 5.3 Chernobyl.

167 The Chernobyl Forum, *op. cit.*, p. 14.

6.177 The estimates also make the LNT assumption described above; that risk continues in a linear fashion at lower doses. The Chernobyl Forum notes that small differences in the assumptions about the risks from exposure to low level radiation can lead to large differences in the predictions of the increased cancer burden, and hence 'predictions should be treated with great caution, especially when the additional doses above natural background radiation are small.'[168]

6.178 Among its other findings, the Chernobyl Forum concludes that:

- Of the 134 emergency workers (referred to as 'liquidators') diagnosed with acute radiation sickness after the accident, 28 persons died in 1986. Nineteen more died of various causes over the period 1987–2004; however, not all these deaths were directly attributable to radiation exposure. Two more persons died at Unit 4 from injuries unrelated to radiation, and one additional death was thought to have been due to a coronary thrombosis.
- Emphasising the caveats noted above, Chernobyl Forum projections for cancer mortality indicate that, among the most exposed populations (a population of 600 000 people comprised of liquidators, evacuees and residents of the most contaminated areas), total cancer mortality might increase by up to 3–4 per cent owing to Chernobyl-related radiation exposure. This might eventually represent up to 4 000 fatal cancers over the lifetime of the most exposed populations.[169]
- Among the six million persons residing in other contaminated areas of Belarus, Russia and the Ukraine, these people received whole body doses not much higher than doses due to natural background radiation (currently, the vast majority of these populations receive annual effective doses from Chernobyl fallout of less than 1 mSv). Projected mortality increases are more speculative, but are expected to make a difference of less than one per cent in cancer mortality.

  Predictions suggest that up to 5 000 additional cancer deaths may occur in this population from radiation exposure, or about 0.6 per cent of the cancer deaths expected in this population due to other causes. The WHO notes that this estimate is highly uncertain as 'it is based on an average dose of just 7 mSv, which differs very little from natural

168 *ibid*., p. 15. See also: WHO, *The Health Effects of Chernobyl: An Overview*, Fact Sheet No. 303, April 2006, viewed 28 September 2006, <http://www.who.int/mediacentre/factsheets/fs303/en/index.html>.

169 WHO, *Health effects of the Chernobyl accident and special care programs*, Report of the UN Chernobyl Forum Group 'Health', WHO, Geneva, 2006, p. 106, viewed 28 September 2006, <http://www.who.int/ionizing_radiation/chernobyl/who_chernobyl_report_2006.pdf >.

background radiation.'[170] The radiation-induced increases will also be difficult to detect with available epidemiological tools, given the normal variation in cancer mortality rates.[171]

The predictions of excess cancer deaths in populations exposed as result of Chernobyl accident are listed in table 6.6.

The WHO notes that the Chernobyl accident may also cause cancers elsewhere in Europe, outside Belarus, the Russian Federation and Ukraine. However, according to UNSCEAR, the average dose to these populations is much lower and so the relative increase in cancer deaths is expected to be much smaller. Predicted estimates are very uncertain and it is very unlikely that any increase in these countries will be detectable using national cancer statistics.[172]

- Among more than 4 000 cases of thyroid cancer diagnosed in 1992–2002 in persons who were children or adolescents at the time of the accident, some nine cancer deaths had been documented by 2002. However, the survival rate is almost 99 per cent.[173]
- Studies of residents in the contaminated areas of Belarus, Ukraine and Russia have not provided clear and convincing evidence for radiation-induced increase in general population mortality, and in particular, for fatalities caused by leukaemia, solid cancers (other than thyroid cancer) and non-cancer diseases.[174]
- Contrary to the assertions of some submitters, the Forum found that there is no evidence, or any likelihood of observing, decreased fertility, increases in congenital malformations or hereditary effects attributable to radiation exposure among the populations of the Chernobyl affected regions.[175]

170 *ibid*.
171 WHO, *The Health Effects of Chernobyl: An Overview*, *loc. cit*.
172 *ibid*.
173 WHO, *Health effects of the Chernobyl accident and special care programs*, *op. cit.*, p. 104.
174 The Chernobyl Forum, *op. cit.*, p. 16.
175 *ibid.*, p. 19. See for example: Mr Daniel Taylor, *Submission no. 85*, p. 6.

Table 6.6 Predictions of excess deaths from solid cancers and leukaemia over lifetime (up to 95 years) in populations exposed as a result of the Chernobyl accident

Population	Population size / average dose	Predicted excess cancer deaths
Liquidators, 1986–1987	200 000 100 mSv	2 200
Evacuees from 30 km highly contaminated zone surrounding the reactor	135 000 10 mSv	160
Residents of strict control zones	270 000 50 mSv	1 600
Sub total		*3 960*
Residents of other 'contaminated' areas	6 800 000 7 mSv	4 970
Total		8 930

Source Adapted from WHO, *Health effects of the Chernobyl accident and special care programs*, p. 108.

6.179 The MAPW (Victorian Branch) were critical of the Chernobyl Forum's estimates and claimed that they were 'incomplete and underestimate the health consequences of the disaster.'[176] Adding estimates for other groups, such as additional liquidators that the MAPW believes the Chernobyl Forum has not included in its analysis and estimates for deaths in future generations, MAPW arrived at an estimated death toll of 34 200 to 38 500.[177]

6.180 In research published by the International Agency for Research on Cancer (IARC) in April 2006, *Estimates of the Cancer Burden in Europe from Radioactive Fallout from the Chernobyl Accident*, it was concluded that cancer incidence and mortality in Europe do not, at present, indicate any increase in cancer rates—other than thyroid cancer in the most contaminated regions—that can be clearly attributed to radiation from the Chernobyl accident. However, the study found that for Europe up to 2065 (i.e. at end of the average life expectancy of Europeans born at the time of the accident in 1986) about 16 000 cancer deaths may occur that are attributable to Chernobyl. The study notes that the uncertainty associated with this prediction is large. As noted by the Chernobyl Forum, the study also found that because these possible deaths represent only a very small fraction of the total number of cancers seen since the accident and expected in the future in Europe, it is unlikely that the cancer burden from

176 MAPW (Victorian Branch), *Submission no. 30.1*, p. 11.

177 *ibid.*, p. 16.

the accident could be ever be detected by monitoring national cancer statistics.[178]

6.181 When asked by the Committee to explain the variance between the Chernobyl Forum's findings and claims that many thousands of deaths have occurred *already*, Dr Caldicott and the MAPW alleged that the Chernobyl Forum's report was a 'whitewash'.[179] It was also claimed that, due to an agreement entered into with the IAEA in 1959, the WHO has been prevented from undertaking any epidemiological studies of radiation victims from Chernobyl and has had diminished independence in relation to radiation health matters more generally.[180]

6.182 The Chernobyl Forum's conclusions were also disputed because the latency period before cancer reveals itself was said to be up to 70 years, and thus to have undertaken a study 'only 20 years post Chernobyl' was said to be too early.[181] Dr Caldicott also claimed that there had been 7 000 cases of thyroid cancer and disputed, without evidence, the Chernobyl Forum's findings that there have actually been between 4 000 and 5 000 cases and, of these, only 15 people have died to date with thyroid cancer having very high survival rates (almost 99 per cent).[182]

6.183 The ANA, among others, expressed frustration with Dr Caldicott's position and responded with the observation that:

> We know the results of the United Nations study by eminent experts. They are not all working for the IAEA. These eminent experts looked at all of the figures and said, 'We think the initial estimates have been grossly overestimated. This many have died, this many have had thyroid cancer and this many may die, but it is in the thousands, not the hundreds of thousands.' [Dr Caldicott] disputes that by saying that we have not waited long enough. If we wait another 20 years there will be many more. You cannot prove her wrong because we have not got there yet.[183]

6.184 However, the Chernobyl Forum states that for most solid cancers the latency period is likely to be longer than for leukaemia or thyroid cancer (some 10 to 15 years longer—i.e. about 20–25 years after the accident), and

178 E Cardis et. al, *The Cancer Burden from Chernobyl in Europe: Briefing Document,* WHO/IARC, April 2006, viewed 28 September 2006, <http://www.iarc.fr./chernobyl/briefing7.php>.

179 Dr Helen Caldicott, *Transcript of Evidence*, 16 September 2005, pp. 5, 6; Dr Stephen Masters (MAPW – WA Branch), *Transcript of Evidence*, 23 September 2005, p. 39.

180 MAPW (Western Australian Branch), *Submission no. 8*, p. 6; MAPW (Victorian Branch), *Submission no. 30.1*, pp. 12–14; Dr Helen Caldicott, *op. cit.*, p. 5.

181 Dr Helen Caldicott, *loc. cit.*

182 *ibid*.

183 Dr Clarence Hardy (ANA), *Transcript of Evidence*, 16 September 2005, p. 60.

hence it may be too early to evaluate the full radiological impact of the accident. Accordingly, the Forum recommends that medical care and annual examinations of highly exposed Chernobyl workers should continue.[184]

6.185 Rather than radiation exposure posing the greatest threat to the affected populations, the Chernobyl Forum clearly states that:

> The most pressing health concerns for the affected areas … lies in poor diet and lifestyle factors such as alcohol and tobacco use, as well as poverty and limited access to health care.[185]

6.186 The report also states that the largest public health problem caused by the accident has been the mental health impact, in part due to the trauma associated with the resettlement of some 330 000 people from the most affected areas. Populations in the affected areas are said to exhibit strongly negative attitudes in self-assessments of health and well-being, and a strong sense of lack of control over their own lives. This is said to have been exacerbated by widespread mistrust of official information and designation of the population as 'victims' rather than as 'survivors'.[186]

6.187 The report emphasises that exaggerated or misplaced health fears, a sense of victimisation and a dependency culture created by government policies is widespread in the affected areas:

> … misconceptions and myths about the threat of radiation persist, promoting a paralysing fatalism among residents. This fatalism yields both excessively cautious behaviour (constant anxiety about health) and reckless conduct …[187]

6.188 At the release of the report, the Chairman of the Chernobyl Forum, Dr Burton Bennett, stated that:

> This was a very serious accident with major health consequences, especially for thousands of workers exposed in the early days who received very high radiation doses, and for the thousands more stricken with thyroid cancer. By and large, however, we have not found profound negative health impacts to the rest of the population in surrounding areas, nor have we found widespread

184 The Chernobyl Forum, *op. cit.*, p. 19; WHO, *Health effects of the Chernobyl accident and special care programs*, *op. cit.*, p. 106.

185 The Chernobyl Forum, *op. cit.*, p. 37.

186 *ibid.*, pp. 21, 35.

187 *ibid.*, p. 41.

> contamination that would continue to pose a substantial threat to human health, with a few exceptional, restricted areas.[188]

6.189 Similarly, the Manager of the WHO's Radiation Program, Dr Michael Repachioli, stated that:

> … the health effects of the accident were potentially horrific, but when you add them up using validated conclusions from good science, the public health effects were not nearly as substantial as had at first been feared.[189]

6.190 The Director General of the IAEA commented that while the impacts of the accident were severe, nonetheless:

> … the situation was made even worse by conflicting information and vast exaggerations—in press coverage and pseudo-scientific accounts of the accident—reporting, for example, fatalities in the tens or hundreds of thousands.[190]

6.191 Dr Ron Cameron of ANSTO submitted that:

> People often ask, 'What about Chernobyl?' Chernobyl was a tragic accident in the nuclear industry. It occurred with a reactor which would never have been built in a Western country. I know that because when I was in the United Kingdom we did an assessment of the Chernobyl RBMK reactor. The conclusion in the report was that we could never license such a reactor in any Western country. The comparison between that and Three Mile Island, which was a Western design, is that they both had a meltdown but there were no injuries or deaths to go with Three Mile Island. That is because it had a strong containment building et cetera.
>
> The latest report on Chernobyl has just been produced, which is after 20 years. The estimate is now 56 deaths after 20 years. That was 31 immediate deaths and a number of people have died since. There have been 4,000 cases of thyroid cancer, but thyroid cancer is a very survivable cancer. Only nine people have died. So that takes the number up to 56 after 20 years. They say that the worst case they could predict—taking into account even the most conservative assumptions and people who got very small doses

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188 Cited in IAEA, 'Chernobyl: The True Scale of the Accident', *Press Release*, 5 September 2005, viewed 25 September 2006, <http://www.iaea.org/NewsCenter/PressReleases/2005/prn200512.html>.

189 Cited in IAEA, 'Chernobyl: The True Scale of the Accident', *loc. cit*.

190 IAEA, 'The enduring lessons of Chernobyl', *Statement of the Director General*, 6 September 2005, viewed 25 September 2006, <http://www.iaea.org/NewsCenter/Statements/2005/ebsp2005n008.html>.

> but have a certain probability of dying—would be that you might get 4,000 over the whole lifetime.[191]

6.192 ANSTO also sought to place the 56 fatalities to date from the Chernobyl accident in the context of fatalities in other industries, which have far outnumbered those that have or may be attributed to Chernobyl:

> If you compare that with Bhopal, which was the chemical accident in 1984, just two years before Chernobyl, that killed 4,000 people immediately and 15,000 people within two years. In 1996, nearly 3,500 people died in China as a result of mining accidents. If you take Australia, which probably has the safest mining industry in the world, 281 coalminers have died since 1902; in New South Wales, 112 have died since 1979.[192]

6.193 As noted by the UIC and ANSTO, Mr Jerry Grandey also pointed out that the accident involved a Soviet designed reactor which would never have been licensed in the West. Mr Grandey also observed that the TMI and Chernobyl accidents have affected public perceptions of the safety of nuclear power and 'we have been living with that and responding to it as an industry since they occurred in 1979 and 1986.'[193]

6.194 In particular, Mr Grandey noted that in Eastern Europe, where similar reactors to those that operated at Chernobyl are still being used, considerable effort has been put into retrofitting the reactors to enhance safety and bring them up to Western standards. These activities have occurred under the oversight of the IAEA and Euratom, with the result that:

> … those that remain operating—and a number of them have been shut down—are as safe as those Western style reactors that are operating in Europe. A number of them, however, are scheduled to be phased out and shut down as a condition of accession to the European Union. In Lithuania, Bulgaria and Hungary these phase-outs will occur between now and 2007. So the technology that would be viewed as Soviet technology that cannot meet Western standards will be largely phased out, but in the interim it has been upgraded considerably.[194]

6.195 Although retrofitting of reactors in Russia has not had the same degree of international oversight, upgrades of Russian reactors have been carried out by the country's ministry of atomic energy. Mr Grandey argued that

191 Dr Ron Cameron (ANSTO), *Transcript of Evidence*, 13 October 2005, pp. 9–10.

192 *ibid.*, p. 10.

193 Mr Jerry Grandey, *op. cit.*, p. 11.

194 *ibid.*

within the nuclear industry the 'conventional view of Russian technology today is that it is as safe as, if not more robust than, some of the Western technology'.[195]

6.196 The UIC confirms these observations, noting that modifications have been made to overcome deficiencies in the 12 RBMK reactors still operating in Russia and Lithuania. Among other modifications, these have removed the danger of a positive void coefficient response, as occurred at Chernobyl. Automated inspection equipment has also been installed in these reactors. Later Soviet-designed reactors are said to be very much safer and the most recent ones have Western control systems or the equivalent, along with containment structures.[196]

6.197 More generally, the UIC notes that the Chernobyl accident led to the development of a safety culture in the former Soviet union, which has been encouraged by increased collaboration between East and West, and substantial investment in improving reactors. Over 1 000 nuclear engineers from the former Soviet Union have visited Western nuclear power plants since 1989 and over 50 twinning arrangements are now in place between East and Western nuclear plants, largely under the auspices of WANO. The UIC notes a number of other international developments aimed at improving nuclear safety in former Eastern bloc countries.[197]

6.198 Dr Rod Hill of the CSIRO argued that assessments must be made of the balance between the risk of an accident occurring and the consequences of the accident:

> We will always be grappling with that difference in relation to nuclear energy, I believe. The fear is that, although terribly unlikely, the consequence in the public's view is significant. My understanding is that the new generation of nuclear reactors significantly reduces the likelihood of a high-consequence incident … but one must balance that consequence of a potential accident, whatever form that may take, against the continuing, ongoing damage we are doing to our environment by the burning of carbon based fuels, unless we find a solution to that.[198]

6.199 In contrast, the UIC argues that the assertion that nuclear reactor accidents are 'the epitome of low-probability but high-consequence' risks is not accurate, as the consequences of an accident are likely to be much less

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195 *ibid*.

196 UIC, *Safety of Nuclear Power Reactors, loc. cit*.

197 See: UIC, *Chernobyl Accident, loc. cit*.

198 Dr Rod Hill (CSIRO), *Transcript of Evidence*, 19 August 2005, p. 8.

severe than those from other industrial and energy sources, as evidenced by data in the following section.[199]

6.200 BHP Billiton also submitted that the response to the TMI accident shows that nuclear accidents can be successfully contained:

> I think even Three Mile Island can be taken as an example of how well things can be done rather than how badly things can be done, because that accident was contained and managed. I think you could use that to make a case that, even when things go … wrong, this can still be a viable and safe way of generating energy.[200]

Nuclear power compared to other energy sources

6.201 The UIC argued that, in comparison to other energy sources, nuclear power has a superior safety record, as indicated by the data for immediate fatalities and injuries from energy accidents for the period 1969 to 1996 in tables 6.7 and 6.8 below.

Table 6.7 Severe energy accidents with the five highest number of immediate fatalities (1969–1996)

Energy source	**Date**	**Country**	**Phase**	**Fatalities**
Oil	Dec 1987	Philippines	Transport	3 000
Oil	Nov 1982	Afghanistan	Distribution	2 700
Hydro	Aug 1979	India	Power plant	2 500
Hydro	Aug 1993	China	Power plant	1 250
Hydro	Sept 1980	India	Power plant	1 000
Chernobyl				
Nuclear	April 1986	Ukraine	Power plant	31

Source Uranium Information Centre, *Submission no. 12*, p. 11.

199 UIC, *Safety of Nuclear Power Reactors, loc. cit*.

200 Dr Roger Higgins (BHP Billiton Ltd), *Transcript of Evidence*, 2 November 2005, p. 23.

Table 6.8 Severe energy accidents with the five highest number of injured (1969–1996)

Energy source	Date	Country	Phase	Injuries
Natural gas	Nov 1984	Mexico	Distribution	7 231
Oil	Jan 1980	Nigeria	Extraction	3 000
Oil	April 1982	Mexico	Distribution	1 400
Oil	Oct 1988	Russia	Distribution	1 020
Oil	Dec 1982	Venezuela	Power plant	1 000
Chernobyl				
Nuclear	April 1986	Ukraine	Power plant	370

Source Uranium Information Centre, *Submission no. 12*, p. 11.

6.202 These claims are supported by the findings of a substantial and widely cited study, *Comprehensive Assessment of Energy Systems: Severe Accidents in the Energy Sector*, undertaken by the Paul Scherrer Institut (PSI) in Switzerland for the Swiss Federal Office of Energy, published in 1998. The study derived severe accident damage indictors, which were calculated for all stages of the energy production chains for coal, oil, natural gas, LPG, hydro and nuclear. The data, which is provided per terawatt-year (TWa) of electricity generated, is listed in table 6.9. The Chernobyl accident resulted in some 31 immediate fatalities (in 1986) and is shown in the table as having caused 8 fatalities per TWa of electricity generated.

Table 6.9 Severe accident damage indicators based on worldwide records (1969–1996)

Energy source	Immediate fatalities per TWa*	Injuries per TWa	Evacuees per TWa	Monetary damage (1996 US$ million)
LPG	3 280	13 900	522 000	1 740
Hydro	883	195	34 200	620
Oil	418	441	7 220	637
Coal	342	70	0	20.4
Natural gas	85	213	5 900	86.8
Nuclear	8	100	75 700	93 500

Source Adapted from Paul Scherrer Institut, *Severe Accidents in the Energy Sector*, p. 291.
* Figures converted from gigawatt years in the PSI study to TWa by the Canadian Nuclear Association to provide a table composed of whole numbers.

6.203 The data indicates that, in terms of immediate loss of life in severe accidents per unit of electricity generated, nuclear power is by far the safest of all forms of energy generation. The next safest, natural gas, has a fatality rate 10 times that of nuclear, coal is some 43 times that of nuclear and hydro has a fatality rate more than 100 times greater than nuclear.

6.204 The study also provides data for severe accidents in OECD and non-OECD records. In terms of the numbers of immediate fatalities per unit of electricity generated, nuclear is again by far the safest form of energy generation in both groups of countries. In the OECD countries, the study records that nuclear power has caused no fatalities or injuries, and is also the safest when delayed fatalities are included (i.e. the latent fatalities due to Chernobyl).[201]

6.205 The report states that while the fatality numbers are highly reliable, the numbers injured and monetary damage are less certain and must be interpreted with caution. Furthermore, while the economic loss associated with the Chernobyl accident is highly dominant, the report notes that estimates for the monetary damage due to the accident vary by an order of magnitude, from US$20 billion to $320 billion.[202]

6.206 The number of delayed fatalities associated with the Chernobyl accident, which was discussed in the preceding section, may rise to some 9 000 over the lifetime of the most exposed populations. In terms of the delayed fatality rates for nuclear, the PSI study states that:

> … in view of the drastic differences in design, operation and emergency procedures, the Chernobyl-specific results are considered not relevant for the 'Western World.'[203]

6.207 Probabilistic safety assessments of plant-specific health risks of representative western nuclear plants (two in the US and one in Switzerland) found a difference of several orders of magnitude between Chernobyl-based estimates of the frequency of delayed fatalities and probabilistic plant-specific estimates for the representative Swiss and US plants.[204]

6.208 FOE claimed that the burning of fossil fuels leads to a large number of fatalities due to the emission of toxic gases and particulates. However, it was claimed that, in addition to delayed fatalities due to Chernobyl, the data in table 6.9 fails to include an estimate of the fatalities arising from the routine radioactive emissions from nuclear fuel cycle facilities. As noted in the discussion of exposures to the public from the fuel cycle above, FOE and others claimed that about 80 000 fatal cancers are caused by routine operations of fuel cycle facilities. These submitters concluded that:

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201 PSI, *Comprehensive Assessment of Energy Systems: Severe Accidents in the Energy Sector*, PSI, Villigen, Switzerland, 1998, pp. 298, 292, viewed 26 September 2006, <http://gabe.web.psi.ch/pdfs/PSI_Report/ENSAD98.pdf>.

202 *ibid.*, pp. xix, 277.

203 *ibid.*, p. 298.

204 *ibid.*, p. 278.

> Compared to the overall fatalities from fossil fuel electricity or nuclear power, renewable energy sources—including hydroelectricity—are much safer.[205]

6.209 In addition to the catastrophic events listed in the tables above, the UIC noted that 6 027 workers died in 3 639 separate accidents in Chinese coal mines in 2004 alone. On average, there are 4.2 fatalities per million tonnes (Mt) of coal mined in China. This compares with 7 fatalities/Mt in Ukraine, 0.034/Mt in the US, and 0.009/Mt in Australia.[206]

6.210 The UIC noted that China plans to more than quadruple its nuclear power capacity to 40 gigawatts electric (GWe) (to 4 per cent of total projected electricity demand) by 2020, which will obviate the need to mine an additional 17 Mt per year of coal for power generation—thus avoiding some 71 additional coal-related deaths per year, based on the average fatality rate mentioned above.

6.211 However, ANSTO observed that even in Australia, with the safest coal mining record in the world, there have been 112 coal mining deaths in NSW alone since 1979 and 281 deaths Australia-wide in 18 major disasters since 1902. In comparison, there have been three deaths from accidents at uranium mines in Australia since 1979.[207]

6.212 Jindalee Resources and others argued that:

> Uranium mining is one of the safest industries operating in Australia. Whilst the special nature of uranium mining is recognised, and appropriate mine management systems are essential for the health and safety of all involved, uranium has been mined successfully in Australia for over 30 years without any serious loss of life or health associated issues. In contrast, coal mining world wide causes the deaths of 12,000 to 15,000 miners a year with China alone reporting 6,027 … deaths in 2004 and 6,200 in 2003.[208]

6.213 However, in comparing the numbers of fatalities in the coal industry with those in the nuclear industry, Dr Caldicott argued that for nuclear power:

> … workers are not followed up epidemiologically and it takes them up to 50 or 60 years to get their cancers, whereas when people are killed in coal mines you know because they are killed

205 FOE et. al., *Exhibit no. 71, op. cit.*, section 5.2.

206 UIC, *Submission no. 12*, p. 12.

207 ANSTO, *Submission no. 29.1*, p. 1; Dr Ron Cameron (ANSTO), *Transcript of Evidence*, 13 October 2005, p. 10. There has been one death at Ranger (in 1996) and two deaths at Olympic Dam (1992 and 2005).

208 Jindalee Resources Ltd, *Submission no. 31*, p. 3. See also: Mr Andrew Crooks, *Submission no. 84*, pp. 11, 17.

> that day … we are talking about something that is going to affect people and other species for the rest of time … when a cancer arises it does not denote its origin. This material is highly carcinogenic.[209]

6.214 Nonetheless, Jindalee Resources observed that while much is made of radiation risks associated with uranium mining, there is no public awareness that coal-fired power stations generate large quantities of fly-ash that is highly radioactive:

> I find it fascinating that if you go to a coal-fired power station and you look at the fly-ash that is around the power station, it is as radioactive as hell. The point that the public does not realise is that all coal is radioactive. At one stage I was in a plane and we had a big sodium iodide crystal to do some uranium exploration in South Australia. We flew over the Sir Thomas Playford power station at Port Augusta and we got the biggest uranium anomaly you have ever seen—from the fly-ash around the base of the coal-fired power station. One thing that people do not realise is that all fossil fuels are radioactive to some degree. In its concentrated form, with all the residue, coal is fiercely radioactive …[210]

6.215 Similarly, Summit Resources observed that:

> … it should also be noted that coal also contains uranium and generates radiation. Crustal uranium is readily dissolved by oxygen in rainwater and then by way of the water table flows downstream and when these ground waters come into contact with coal, mostly carbon and a natural reducing agent, the uranium is precipitated onto the coal which contains orders of magnitude more uranium than the average crustal material. Unlike nuclear plants, coal fired power stations do not 'burn' the uranium or manage their contaminated waste. The uranium is either sent up the smoke stack or left as contaminated fly ash waste at the plant.[211]

6.216 While conceding that nuclear power's safety record is 'encouraging', AMP CISFT also argued that this doesn't necessarily provide evidence that nuclear power is 'safe':

> For example, if nuclear reactors are designed to have an offsite fatality frequency of less than 1 every 10 million years, the calculated probability that there has been any accident leading to

209 Dr Helen Caldicott, *Transcript of Evidence*, 16 September 2005, p. 15.

210 Mr Donald Kennedy (Jindalee Resources Ltd), *Transcript of Evidence*, 23 September 2005, p. 58.

211 Summit Resources Ltd, *Submission no. 15*, p. 33.

> an offsite fatality from any of the commercial reactors, with a total of 11 000 reactor operating years, is approximately 0.11%.[212]

6.217 Summit Resources stated emphatically that 'the nuclear power industry is the safest form of power generation that man has used to date.'[213] In addition to the statistics for deaths of coal miners cited earlier, Mr Eggers noted that, in terms of deaths at power stations:

> … coal-fired power stations since 1997 have killed 6,500 people; natural gas, 1,200 people; hydro, 4,000 and maybe more, but this is usually to do with dam failures; and the nuclear industry has killed 31 people.[214]

6.218 Summit Resources also compared the risks associated with the transport of LNG:

> Here in Australia LNG is a very hazardous product. It is also a terrorist target. One of these tankers leaving the North West Shelf has the equivalent of 55 Hiroshima bombs sitting in it. This is mitigated, but, as we all know, it could cause up to hundreds of thousands of deaths in a major city where they deliver this fuel. Since 1989, Australia has shipped 1,600 shipments of these cargoes out of Australia without incident, due to a stringent safety regime.[215]

6.219 Nova Energy argued that risks in the mining of uranium are well understood and managed successfully:

> Continued developments in operational health and safety in the mining industry mean that the risks in the mining and handling of uranium are well understood and standard operating procedures are well used. Similarly, advances in the nuclear energy generating technologies clearly demonstrate a growing maturity in that industry.[216]

6.220 In relation to the routine operations of the nuclear power industry, the Committee also notes that the Fox Inquiry report concluded that:

> … while the operations of the nuclear power industry need close regulation and close surveillance, they probably do *not* entail risks greater in sum than those inherent in alternative energy industries. Certainly those risks provide *no proper basis* for a refusal on our

212 AMP CISFT, *op. cit.*, p. 6.

213 Mr Alan Eggers (Summit Resources Ltd), *Transcript of Evidence*, 3 November 2005, p. 2.

214 *ibid.*, p. 3.

215 *ibid.*

216 Mr Richard Pearce (Nova Energy Ltd), *Transcript of Evidence*, 23 September 2005, p. 69.

> part to supply the advanced industrial countries which are likely to be our customers.[217]

Terrorism and the safety of nuclear facilities

6.221 A principal concern of some submitters was the alleged vulnerability of nuclear power plants (NPPs) and other nuclear facilities to acts of terrorism. The IAEA has likewise identified the possible radiological hazards caused by an attack on, or sabotage of, a nuclear facility or a transport vehicle as one of four potential nuclear security risks.[218]

6.222 The MAPW (Victorian Branch) argued that:

> Nuclear reactors and associated facilities, particularly spent fuel storage facilities, which contain large quantities of long-lived radioactive substances, potentially pose a highly attractive target for terrorist attack. Indeed considering feasibility, visibility, large number of potential targets, potential for severe consequences, with persistent environmental contamination over large areas and need for costly clean-up, major social disruption following widespread fear and panic and need for evacuation of populations in the fallout path, economic damage and political effect, it is hard to envisage many more attractive potential targets for terrorists.[219]

6.223 MAPW (Victorian Branch) made a number of other claims, including that all current containment structures surrounding reactors could be breached by attacks such as those that occurred at the World Trade Centre (WTC) in New York in 2001. Attacks could also target more peripheral but important components of a plant's operations, such as cooling water conduits or plant safety systems. Simulated attacks on Russian and US reactors are said to have revealed significant vulnerabilities.[220]

6.224 MAPW and Dr Helen Caldicott also argued that spent fuel storage tanks are even more vulnerable than reactors, because these are allegedly often housed in simpler buildings with less robust containment structures. It was also argued that an attack on a reprocessing plant or spent fuel pools could result in greater and longer-lived radioactivity release than

217 Mr R W Fox, *op. cit.,* p. 177. Emphasis added.

218 See: Dr Mohamed ElBaradei, *Nuclear Terrorism: Identifying and Combating the Risks*, Statement of the Director General, IAEA, Vienna, 16 March 2005, viewed 14 July 2006, <http://www.iaea.org/NewsCenter/Statements/2005/ebsp2005n003.html>.

219 MAPW (Victorian Branch), *Submission no. 30*, p. 13.

220 *ibid*., p. 14.

following an attack on a reactor, because spent fuel pools contain larger concentrations of radioactivity than a reactor core.[221] It was submitted that:

> Thus even without the use of nuclear weapons, targeting of operating nuclear reactors and/or associated fuel storage or reprocessing facilities would essentially convert a war to a nuclear war, and a conventional terrorist attack into a nuclear attack.[222]

6.225 While it was conceded that preventative security measures are being implemented to reduce the likelihood of a successful attack, 'in the long-term only the complete dismantling of nuclear power plants will fully prevent such a devastating eventuality.'[223]

6.226 The UIC states that, since the events of 11 September 2001, various studies have examined similar attacks on nuclear power plants and, contrary to the MAPW's claims, these have concluded that reactor structures would protect reactor fuel from impacts of large commercial aircraft. One study, funded by the US Department of Energy, used a fully-fuelled Boeing 767-400 weighing over 200 tonnes flying at 560 km/hr. This study found that no part of the aircraft or its fuel would penetrate the containment structure. The analyses also showed no breach of spent fuel storage pools and that transport casks retained their integrity.[224]

6.227 In another test, conducted in 1988 by the Sandia National Laboratories (SNL) in the US, a rocket-propelled F4 Phantom jet was flown into concrete at 765 km/hr (to test whether a proposed Japanese nuclear power plant could withstand the impact of a heavy aircraft). The maximum penetration of the concrete in this experiment was six centimetres.[225]

6.228 Mr Stephen Mann, representing Areva, submitted that:

> I do not think the general population understand or realise the safeguards that exist now following the September 11 incidents. People were talking about aeroplanes flying into nuclear reactors. Aeroplanes can fly into any of the modern nuclear reactors and it would automatically shut down. There would not be any contamination. I do not think people really understand that.[226]

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221 MAPW (Victorian Branch), *Exhibit no. 52, Vulnerability of Us nuclear power plants to terrorists*, p. 2; Dr Helen Caldicott, *Exhibit no. 24, op. cit.*, p. 2.

222 MAPW (Victorian Branch), *Submission no. 30*, p. 14.

223 Cited in MAPW (Victorian Branch), *Exhibit no. 54, Nuclear Power and the Terrorist Threat*, p. 1. See also: FOE et. al., Exhibit no. 71, *Nuclear Power: No solution to climate change*, section 3.8.

224 See: NEI, *Deterring Terrorism: Aircraft Crash Impact Analyses Demonstrate Nuclear Power Plant's Structural Strength*, December 2002, viewed 29 September 2006, <http://www.nei.org/documents/EPRINuclearPlantStructuralStudy200212.pdf>.

225 UIC, *Safety of Nuclear Power Reactors, loc. cit*.

226 Mr Stephen Mann (Areva), *Transcript of Evidence*, 23 September 2005, p. 10.

6.229 Among its other responses to the WTC attacks, the NRC began an accelerated security and engineering review. The review looked at what could possibly happen if terrorists used an aircraft to attack a nuclear power plant. The potential consequences of other types of terrorist attacks were also assessed. The NRC analysed what might happen as a result of such attacks and what other factors might affect the possibility or magnitude of a radiation release.[227]

6.230 The NRC states that as part of the security review it has conducted detailed engineering studies of a number of nuclear power plants. The studies at the specific facilities confirmed that the plants are robust. It was also found that even in the unlikely event of a radiological release due to a terrorist attack, there would be time to implement the required offsite planning strategies already in place to protect public health and safety.

6.231 In relation to the security of spent fuel storage, the NRC considers spent fuel storage facilities to be robust so that in the event of a terrorist attack similar to those of 2001, no negative effect on the storage of radioactive materials would result. The NRC states that spent fuel pools and dry storage casks do not have flammable material to fuel long-duration fires, unlike the structures that were destroyed in the events of September 2001. However, the NRC states that it is conducting an evaluation that includes consideration of potential consequences of terrorist attacks using various explosives or other techniques on spent fuel pools and dry storage casks.[228]

6.232 Since September 2001 NPP security has been significantly strengthened and the NRC has issued new security requirements for plant sites. All US plants have met these requirements. NPPs must meet the highest security standards of any industry in the US. Since 2001, the US nuclear power industry has spent an additional US$1.2 billion on security-related improvements.[229]

6.233 More generally, the NEI states that the defence-in-depth philosophy used in the construction and operation of NPPs provides high levels of protection for public health and safety.[230] In addition to the reactor containment and reactor vessel construction, which are designed to be

227 NRC, *Frequently Asked Questions About Security Assessments at Nuclear Power Plants*, viewed 29 September 2006, <http://www.nrc.gov/what-we-do/safeguards/faq-security-assess-nuc-pwr-plants.html#1>.

228 NRC, *Frequently Asked Questions About NRC's Response to the 9/11/01 Events*, viewed 29 September 2006, <http://www.nrc.gov/what-we-do/safeguards/faq-911.html#17>.

229 NEI, *Post-Sept. 11 Security Enhancements: More Personnel, Patrols, Equipment, Barriers*, viewed 29 September 2006, <http://www.nei.org/index.asp?catnum=2&catid=275>.

230 NEI, *Nuclear Power Plant Security*, March 2005, viewed 29 September 2006, <http://www.nei.org/doc.asp?catnum=3&catid=290>.

impervious to catastrophes and to airborne objects up to a certain force, NPPs have:

- fortified physical barriers to resist penetration;
- armed security forces and advanced surveillance equipment;
- use of mock drills that ensure industry can protect against a threat by a well-trained paramilitary force intent on forcing its way into a plant to commit sabotage, armed with automatic weapons and explosives, with the assistance of an 'insider' who could pass along information and help to the attackers; and
- personnel procedures to protect from internal threats.[231]

6.234 Among a range of international initiatives to enhance nuclear security, in 2005 the UN General Assembly adopted the *International Convention for the Suppression of Acts of Nuclear Terrorism*. The Convention details offences relating to unlawful and intentional possession and use of radioactive material or a radioactive device, and use or damage of nuclear facilities. The Convention requires States Parties to make every effort to adopt appropriate measures to ensure the protection of radioactive material.[232]

6.235 The Committee addresses other security risks, including the risk of terrorist groups acquiring nuclear materials for the construction of nuclear weapons and the potential for Australian Obligated Nuclear Material (AONM) and other radioactive material to be diverted for use in 'dirty bombs', in chapter eight. Other Australian and international efforts to prevent, detect and respond to such attacks are discussed further in chapter eight.

6.236 While written in a different historical and strategic context, the Fox Inquiry report concluded that the risk of nuclear terrorism did not constitute a sufficient reason for Australia declining to supply uranium, but that the matter should be kept under constant scrutiny and control by Government.[233]

Depleted uranium

6.237 Some submitters expressed concerns about alleged health and environmental impacts of the use of depleted uranium, particularly depleted uranium used in munitions. It was also argued that an expansion of uranium mining would automatically lead to an increase in the amount of this material available for weapons production.

231 UIC, *Safety of Nuclear Power Reactors, loc. cit*.

232 IAEA, *IAEA Annual Report for 2005*, 'The year in Review', IAEA, Vienna, 2006, p. 7, viewed 29 September 2006, <http://www.iaea.org/Publications/Reports/Anrep2005/yearreview.pdf>.

233 Mr R W Fox, *op. cit.*, p. 178.

6.238 As described in the overview of the fuel cycle in chapter two, depleted uranium is a product (known as 'tails') of the uranium enrichment process. The UIC explained that every tonne of natural uranium produced and enriched for use in a nuclear reactor gives about 130 kg of enriched fuel (3.5 per cent or more U-235). The balance is depleted uranium (some 99.8 per cent U-238, with some 0.2 percent U-235). This major portion has been depleted in its fissile U-235 isotope by the enrichment process and is commonly known as DU. Consequently, DU is weakly radioactive and a radiation dose from it would be about 60 per cent that from natural uranium with the same mass.[234]

6.239 DU is stored either as UF_6 or it is de-converted back to U_3O_8 which is more benign chemically and thus more suited for long-term storage. It is also less toxic. Every year over 50 000 tonnes of DU is added to already substantial stockpiles in the US, Europe and Russia. World stocks of DU are about 1.2 million tonnes. [235]

6.240 Some DU is drawn from these stockpiles to dilute high-enriched (>90 per cent) uranium (HEU) released from weapons programs, particularly in Russia, and destined for use in civil reactors. This weapons-grade material is diluted about 25:1 with DU, or 29:1 with DU that has been enriched slightly (to 1.5 per cent U-235) to minimise levels of (natural) U-234 in the product.

6.241 Other than for diluting HEU for use as reactor fuel, DU also has applications where its very high density (1.7 times that of lead) is beneficial. DU is used in aircraft control surfaces, helicopter counterweights and yacht keels. The military uses of DU include defensive armour plate and in armour penetrating military ordnance. DU can ignite on impact if the temperature exceeds 600ºC. DU was widely used in the 1991 Gulf War (300 tonnes) and less so in Kosovo (11 tonnes).[236]

6.242 Ms Ilona Renwick submitted that:

> As well as causing severe injuries and death, depleted uranium remains in the soil or the air and has a half life for millions of years. Its potency remains during this time to cause radiation sickness, cancers, and birth defects.
>
> Death is likely from any one who comes in contact with it – contamination may occur just by working near it - breathing it in. This has been evidenced by the health effects on people who went

234 UIC, *Submission no. 12*, p. 33.

235 See: UIC, *Uranium and Depleted Uranium*, Nuclear Issues Briefing Paper No. 53, October 2005, viewed 29 September 2006, < http://www.uic.com.au/nip53.htm>.

236 *ibid*.

> into Iraq after the first Gulf War in 1991. Many of them have become sick and died.
>
> We have Australians who have been in those locations where the effects have been passed onto their children.[237]

6.243 The Darwin NO-WAR Committee submitted that:

> DU consists of approximately 99% uranium-238 which, while it has a relatively low level of radioactivity, is very dangerous if inhaled or ingested. It is not only radioactive but toxic, with a proven negative effect on DNA, nerve tissues and kidneys. In areas where DU weapons have been used (for example Basra in Iraq) large increases in cancers and birth defects are being observed. Troops stationed in areas where DU weapons have been used, or those who were in DU armoured tanks when they were hit, have been diagnosed with a range of symptoms consistent with radiation poisoning.[238]

6.244 It was argued that the effects of DU weapons reach beyond their immediate target, continue after the war and have an unduly negative impact on the environment: 'They also constitute an unduly inhumane risk for both civilians and combatants.'[239]

6.245 The PHAA also argued that concerns about the use of DU in munitions arose because of health problems suffered by people in Iraq following the 1991 Gulf War. PHAA pointed to UN cancer statistics for southern Iraq which were said to indicate a seven-fold increase in cancer during the period 1989-1994. It was also argued that the incidence of congenital malformations in Iraq has risen sharply since the Gulf War. In addition, many US Gulf War veterans are disabled by a range of symptoms, called Gulf War Syndrome, for which there was said to be no generally accepted explanation.[240]

6.246 Mrs Judy Forsyth also alleged that the :

> US and the UK have used depleted uranium shells in Bosnia and Iraq , causing cancers and leukaemia to thousands of soldiers and civilians. Thousands of Iraqi children have been affected with birth deformities which have been genetically inherited from parents who inhaled or ingested depleted uranium during and after the Gulf War. It is possible that these illnesses will be observed in Australian and other Coalition troops returning from Iraq in the

237 Ms Ilona Renwick, *Submission no. 76.1*, p. 1.

238 Darwin No-WAR Committee, *Submission no. 13*, p. 2.

239 *ibid*., p. 3.

240 PHAA, *op. cit*., p. 2

> same way as US Gulf War veterans and their children were affected.[241]

6.247 Furthermore, Mrs Forsyth argued that there can be no guarantee that Australia uranium, exported to the US and UK, is not being used in the weapons.[242]

6.248 The PHAA urged the Australian Government to seek an immediate international moratorium on the use of DU munitions and an independent study on health and environmental effects of DU, including studies of both the civilian and the military populations that have been exposed.

6.249 The PHAA further urged the Australian Government to ensure that no DU munitions are used on Australian soil (e.g. in joint military exercises) and that no Australian troops join any military coalition in which DU munitions might be used. However, the PHAA acknowledged that the Australian Defence Forces no longer use munitions that contain DU.[243]

6.250 In contrast, the UIC submitted that depleted uranium is not classified as a dangerous substance radiologically. Its emissions are very low, since the half life of U-238 is the same as the age of the earth (4.5 billion years). There were said to be no reputable reports of cancer or other negative health effects from radiation exposure to ingested or inhaled natural or depleted uranium.[244]

6.251 Some military personnel involved in the 1991 Gulf War later complained of continuing stress-like symptoms for which no obvious cause could be found. These symptoms have at times been attributed to the use of depleted uranium in shells and other missiles, which are said to have caused toxic effects. Similar complaints arose from later fighting in the Balkans, particularly the Kosovo conflict.

6.252 Depleted uranium is a heavy metal and, in common with other heavy metals, is chemically toxic. Because it is also slightly radioactive, there is therefore said to be a hypothetical possibility that it could give rise to a radiological hazard under some circumstances such as dispersal in a finely divided form so that it is inhaled. However, because of the latency period for the induction of cancer for radiation, it is not credible that any cases of radiation induced cancer could yet be attributed to the Gulf and Kosovo conflicts. Furthermore, extensive studies have concluded that no radiological health hazard should be expected from exposure to depleted uranium.

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241 Mrs Judy Forsyth, *op. cit.*, p. 4.

242 *ibid.*, p. 1.

243 PHAA, *loc. cit.*

244 UIC, *Submission no. 12*, p. 33.

6.253 Moreover, the UIC argued that the risk from external exposure is essentially zero, even when pure metal is handled. No detectable increase of cancer, leukaemia, birth defects or other negative health effects have ever been observed from radiation exposure to inhaled or ingested natural uranium concentrates, at levels far exceeding those likely in areas where depleted uranium munitions are said to have been used. This is mainly because the low radioactivity per unit mass of uranium means that the mass needed for significant internal exposure would be virtually impossible to accumulate in the body, and depleted uranium is less than half as radioactive as natural uranium.[245]

6.254 Information published by the WHO states that a recent UN Environment Program report, giving field measurements taken around selected impact sites in Kosovo, indicates that contamination by DU in the environment was localised to a few tens of metres around impact sites. Contamination by DU dusts of local vegetation and water supplies was found to be extremely low. Thus, the probability of significant exposure to local populations was considered to be very low.[246]

6.255 A two-year study by SNL reported in 2005 that, consistent with earlier studies, reports of serious health risks from DU exposure during the 1991 Gulf War, both for military personnel and Iraqi civilians, are not supported by medical statistics or by analysis.[247]

6.256 The WHO also noted that because DU is only weakly radioactive, very large amounts of dust (in the order of grams) would have to be inhaled for the additional risk of lung cancer to be detectable in an exposed group. Risks for other radiation-induced cancers, including leukaemia, are considered to be very much lower than for lung cancer. Further, the WHO states that no reproductive or developmental effects have been reported in humans.[248]

6.257 The conditions for the use of AONM set out in Australia's bilateral safeguards agreements, which are discussed at greater length in chapter eight, include the requirement that AONM will be used only for peaceful purposes and will not be diverted to military or explosive purposes. In this context, 'military purpose' includes depleted uranium munitions.

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245 *ibid*.

246 WHO, *Depleted Uranium*, Fact Sheet No. 257, January 2003, viewed 29 September 2006, <http://www.who.int/mediacentre/factsheets/fs257/en/print.html>.

247 See: SNL, *An Analysis of Uranium Dispersal and Health Effects Using a Gulf War Case Study*, SNL, Albuquerque, New Mexico, July 2005, viewed 29 September 2006, <http://www.sandia.gov/news-center/news-releases/2005/def-nonprolif-sec/snl-dusand.pdf>.

248 WHO, *Depleted Uranium*, *loc. cit.*

Radiation and public perceptions

6.258 Throughout the chapter, including in the immediately preceding discussion of the health effects of depleted uranium, the Committee has cited statements of concern about radiation exposure and its effects on human health from various submitters.

6.259 Other submitters responded that these concerns often reveal misunderstandings about the nature of radiation and misperceive the actual risks associated with radiation exposure from the normal operations of fuel cycle facilities, including uranium mining and milling. For example, Nova Energy submitted that:

> Some of these concerns are legitimate and as such they are acknowledged by the international community, and authoritative bodies such as the IAEA have been formed to mitigate specific risk. Other concerns appear to be emotive rather than rational and may, deliberately or otherwise, engender community fear and distrust of uranium mining and nuclear power. This in turn influences political policy. Nova Energy believes it is very important for the Committee to address these issues in its process to provide a fact based discussion for the Australian community.[249]

6.260 As explained at the beginning of the chapter, all human beings are constantly exposed to background radiation and the contribution from nuclear power is less than one per cent. Professor Leslie Kemeny explained that:

> Fear of unseen, unsmelled and untouchable radiation should be tempered by the fact that our global community lives in a radiation field called 'background radiation' which is inescapable and which is a natural variant of human existence just like temperature or humidity. The human body can safely accept large variations of background radiation dose which is a function of altitude, geology, occupation, building materials, sunspot activity, diet and many other factors. Background radiation doses in some buildings or limestone caves or even coal mines are often greater than that in a uranium mine or a nuclear power station!
>
> Around three-quarters of our radiation dose comes from natural sources such as cosmic radiation from the sun, radon gas in the air and radioactive materials in the ground, and in waters and oceans of the world. The human body itself is a significant radiation

249 Nova Energy Ltd, *Submission no. 50*, p. 26.

> source. At close encounter, human beings irradiate each other both day and night.
>
> Approximately one quarter of our background radiation dose arises from some form of human activity, such as medical diagnostic and therapeutic sources, the burning of coal and the use of electronic appliances. Within this segment the contribution from peaceful uses of nuclear energy and from past fallout from nuclear tests is less than 1 per cent.[250]

6.261 Based on his conviction of the hormetic effects of exposure to very low doses of radiation, Professor Peter Parsons also argued that opposition to nuclear power is in part due to 'acceptance by the public of phantom risks from radiation phobia based upon the invalid linear-no-threshold assumption'.[251]

6.262 Several submitters argued that the general understanding of radiation in Australia is poor and should be addressed in schools and through publicly available information. It was emphasised that there is a need for improved public education about the risks associated with radiation:

> The general level of understanding of radiation and radioactive processes in Australia is poor. Education … on nuclear matters needs to be addressed at both the school and general public levels.[252]

6.263 Similarly, Professor Ralph Parsons submitted that:

> Accurate information about the risks associated with ionising radiation must be more widely understood and disseminated before the concerns of the public about further uranium developments can be adequately addressed.[253]

6.264 Likewise, Arafura Resources argued that there is a need for public eduction around the nature and risks associated with radiation exposure:

> The public have to have a basic understanding of the nature of radiation and a point of reference, which might be that the radiation emitted by the sun or an X-ray you get at the surgery—which is beneficial to your health in diagnosing conditions that you may have in your body—can be managed by the dosage level. You might equate it to the same degree that you would allocate a conventional medicine, a Panadol tablet or something like that. You should only have so many Panadol per hour. The same

250 Professor Leslie Kemeny, *Exhibit no. 43, Pseudo-Science and Lost Opportunities*, pp. 4–5.
251 Professor Peter Parsons, *Exhibit no. 23, op. cit.*, p. 2.
252 Name withheld, *Submission no. 25*, p. 2.
253 Professor Ralph Parsons, *op. cit.*, p. 1.

> relative scale would be attributed to radiation. There are standards at the moment—there are ways of measuring and limiting exposure to it. The other issue is that the public think that radiation is being introduced into their lives. They need to know the background radiation level that exists around their lives—around their houses, beaches, rocks … That would be a better point of reference for them. It is about the magnitude. People see radiation as dangerous. They do not appreciate that there are different degrees and scales of radiation.[254]

6.265 Similarly, the Australian Nuclear Forum (ANF) argued that:

> … if decisions are made to move forward with our uranium industry, we submit that governments must prepare the population by giving them clear and simple information on matters of uranium and radiation safety. For too long—for a generation at least—the nuclear industry has suffered from myth and misinformation in the media and the schools, leading to fear in the public mind. There always will be some controversy, but governments have a duty to inform and to lead.[255]

6.266 Professor Kemeny emphasised that commonly held fears about radiation are often created and manipulated by the opponents of nuclear power. Accordingly, Professor Kemeny emphasised the importance of improved public education about nuclear matters and radiation in particular:

> For more than three decades, the Australian community has been assailed with false perceptions of danger or high risk emotively linked with such words as *radiation*, *research reactor* and *uranium*. In the absence of sound education and informed realism, some will react to this with fear and anger …
>
> The false assessment of nuclear risk is a favoured strategy of Australia's radical anti-nuclear activists, self-promoting eco-politicians with hidden agendas. It does not matter whether the infrastructure project is a uranium mine, a new research reactor, a nuclear waste repository or a nuclear plant …The radical activist will construct a threatening scenario to suit an eco-political objective. In this, informed realism, nuclear physics and the laws of probability play no part …
>
> The ultimate weapon of the anti-nuclear activist is it try to establish some causal link between low-level radiation and cancer. This false hypothesis forms the centrepiece of most 'anti-nuclear'

254 Mr Alistair Stephen (Arafura Resources NL), *Transcript of Evidence*, 23 September 2005, p. 51.
255 Mr Jim Brough (ANF), *Transcript of Evidence*, 16 September 2005, p. 43.

> campaigns. It is a powerful way of frightening people and controlling community attitudes …
>
> Many anti-nuclear activists are willing to perpetrate scientific fraud and exercise emotional blackmail in order to create radiation phobia in the minds of their audiences.[256]

6.267 Finally, Professor Kemeny argued that the benefits of nuclear science and technology, in the fields of medicine, industry and environmental science, outweigh any risks:

> In the new millennium there will be increasing use of nuclear science and technology in every field of human endeavour. The immense benefits far outweigh the risks. And the risks of radiation must be assessed on a scientific basis and with informed realism … The manipulative assessment of nuclear risk must not deprive humanity of these immense benefits.[257]

Conclusions

6.268 The Committee concludes that nuclear power, like all other major energy industries, is not and nor could it ever be entirely risk free. However, notwithstanding the tragedy of the Chernobyl accident, the nuclear power industry's safety record surpasses all others.

6.269 In the 50 year history of civil nuclear power generation, which spans more than 12 000 cumulative reactor years of commercial operation in 32 countries, there have been only two significant accidents to nuclear power plants—at Three Mile Island in 1979 and Chernobyl in 1986. Only the Chernobyl accident resulted in fatalities.

6.270 There have been some 60 deaths directly attributed to the Chernobyl accident to date. However, not all these deaths were due to radiation exposure. While there have been more than 4 000 thyroid cancer cases, particularly among children and adolescents at the time of the accident, fortunately there have only been nine deaths documented by 2002. The survival rate has been almost 99 per cent.

6.271 While the precise number of eventual deaths likely to be attributable to the Chernobyl accident is uncertain, the multi UN agency Chernobyl Forum report estimates that excess cancer deaths could rise to 3 960 over the lifetime of the most affected populations (Chernobyl liquidators, evacuees and residents of the strict control zones).

256 Professor Leslie Kemeny, *op. cit.*, pp. 4, 6. Emphasis in original.

257 Professor Leslie Kemeny, *Exhibit no. 9, op. cit.*, p. 3.

6.272 Projections for cancer deaths among some six million residents of contaminated areas in Belarus, the Russian Federation and Ukraine are much less certain because they were generally exposed to doses not much higher than natural background radiation levels. Projections are based on statistical estimates using information from the studies of atomic bomb survivors, who were exposed to much higher radiation dose rates (high doses in a short time period), and employ the conservative linear no-threshold assumption that risk continues in a linear fashion at lower doses. Estimates suggest that up to 4 970 additional cancer deaths may occur in this population from radiation exposure, or about 0.6 per cent of the cancer deaths expected in this population due to other causes.

6.273 That is, while emphasising that predictions should be treated with great caution, the Chernobyl Forum estimates that a total of up to 8 930 excess deaths from solid cancers and leukaemia might be expected over the course of a lifetime in the most exposed populations in Belarus, the Russian Federation and Ukraine. This is a population of more than 7 million people, comprised of Chernobyl liquidators, evacuees, residents of strict control zones and persons living in 'contaminated' areas.

6.274 Other Chernobyl-related radiation induced cancer deaths could occur elsewhere in Europe, although the dose to these populations is much lower again and the relative increase in cancer deaths is expected to be much smaller. Estimates for these populations are very uncertain and are not likely to be detected by monitoring national cancer statistics.

6.275 In any case, the Committee notes the Chernobyl Forum's findings that the most pressing health problems for areas most affected by the accident is *not* radiation exposure but poor life style factors associated with alcohol and tobacco use, as well as poverty. The largest public health problem has been the mental health impact. Persistent 'misconceptions and myths' about the threat of radiation have promoted a 'paralysing fatalism' among residents.

6.276 The Chernobyl accident resulted from a flawed Soviet reactor design which would never have been certified for operation under regulatory regimes of western nations. The reactor was operated with inadequately trained personnel and without proper regard for safety. In addition, the Chernobyl plant did not have a containment structure common to most nuclear plants elsewhere in the world.

6.277 At Three Mile Island in the US, the plant design contained the radiation and there were no adverse health or environmental effects.

6.278 The Chernobyl accident has led to a significant improvement in nuclear reactor safety worldwide, especially in the former Soviet Union where remaining reactors of the Chernobyl type have now been modified and in some cases shut down. The accident also led to increased international collaboration, peer review and knowledge exchange to improve plant safety, especially through the activities of WANO.

6.279 Evidence suggests that, as for many other industries, nuclear reactor technology continues to evolve. For example, some so-called third generation reactor designs are 'passively safe'; not requiring human intervention to prevent core melt accidents. Some fourth generation reactor designs, which represent the future for nuclear energy systems, are immune from the possibility of core melt accidents altogether.

6.280 While the Chernobyl accident could lead, over the lifetime of the most exposed populations, to several thousand excess cancer deaths, other energy sources are responsible for killing thousands of workers and members of the public every year. For example, in addition to catastrophic events (e.g. 3 000 immediate fatalities in an oil transport accident in 1987 and 2 500 immediate fatalities in a hydro accident in 1979), more than 6 000 coal miners die each year in China alone. Evidence suggests that coal mining worldwide causes the deaths of 12 000 to 15 000 miners each year. On this basis, the fatality rate from coal mining worldwide exceeds, in just two days, the fatalities to date from the Chernobyl accident. Even in Australia, 112 coal miners have died in NSW mines alone since 1979.

6.281 Moreover, the numbers of fatalities cited do not include the deaths and other health impacts likely to be caused by the release of toxic gases and particulates from burning fossil fuels. Neither do these considerations consider the possible health impacts and other risks associated with climate change arising from fossil fuel use.

6.282 Naturally, the Committee regrets that fatalities have been caused by any form of energy generation. However, the Committee believes that no base-load power system is without risk of injury or fatalities and, of these, the nuclear's industry's safety performance is demonstrably superior to all others.

6.283 In terms of the health hazards from the routine operations of nuclear fuel cycle facilities, evidence suggests that occupational radiation exposures are low. In fact, the average annual effective dose to monitored nuclear industry workers is less than the exposure of air crew in civil aviation, and is also less than the radon exposure in some above-ground workplaces.

6.284 Globally, exposure by the general public to radiation from the whole fuel cycle is negligible. The average annual natural background radiation exposure is 2.4 mSv. In comparison, the average dose received by the public from nuclear power production is 0.0002 mSv and, hence, corresponds to *less than one ten thousandth* the total yearly dose received from natural background.

6.285 Radiation exposure for workers at Australian uranium mines is well below (less than half) the prescribed average annual limit for workers of 20 mSv. The radiation exposure for the public in the vicinity of the mines is also far below the prescribed level of 1 mSv for members of the public. Indeed, at Beverley in South Australia, the nearest members of the public received a dose less than one hundredth the prescribed limit in 2005.

6.286 The Committee acknowledges there have been incidents at the Ranger mine, for which ERA has been prosecuted. This is evidence of a willingness by regulators to pursue the company where necessary, contrary to the claims by the industry's opponents. The Committee notes that ERA itself acknowledges that its performance in 2004 was not adequate and has taken steps to improve. The Australian Government is satisfied that the company has met the conditions required of it. The Committee also notes that the radiation doses received by workers and the public in the two incidents did not represent a significant health risk.

6.287 The Committee is persuaded that uranium industry workers in Australia are not being exposed to unsafe doses of radiation. However, to provide greater assurance to workers and the public at large, and also to definitively answer claims—which the Committee is confident are entirely mistaken—that current radiation exposures are harming workers, the Committee recommends the establishment of:

- a national radiation dose register for selected occupationally exposed workers; and
- a system of long-term monitoring of the health outcomes for workers occupationally exposed to radiation in uranium mining, associated industries and nuclear facilities.

6.288 It was emphasised that radiation protection standards are largely based on the LNT assumption that all radiation, even very low doses, carries some risk of damage to human health. The Committee well understands that this is the international norm, established by the ICRP, and accepts that basing protection standards on cautious assumptions is prudent. However, the Committee notes that there are arguments pointing to a beneficial effect from exposures to low doses of radiation, consistent with hormesis applicable to other environmental agents.

6.289 The Committee's primary concern is to ensure that fear of health risks from very low doses of radiation not be used as a justification to oppose further uranium mining and utilisation of nuclear power—particularly given that exposures to workers and the public in other industries (e.g. air travel) exceed that for the average nuclear industry worker and that natural background radiation, to which all people are constantly exposed, is significantly greater than the average public dose from the operation of the nuclear power industry.

6.290 In the Committee's view, some critics of uranium mining and nuclear power misconceive or exaggerate the health risks from the industry's operations, for example, by wildly inaccurate assessments of the deaths attributable to the routine operations of the industry. This detracts from the credibility of these submitters—as does the dismissal of the 600-page Chernobyl Forum report as a 'whitewash'. Such views have however influenced wider public opinion and public policy in a way detrimental to the industry, and have reduced the potential community and global benefits from use of nuclear power.

6.291 The Committee agrees that, evidenced by observations made by some submitters, that there are commonly held misperceptions about: the nature of radiation; exposures to the public from the operations of the nuclear power industry, medical procedures and natural background; and the health hazards associated with the nuclear industry's operations. Incorrect and exaggerated claims point to the need for the provision of authoritative information in this highly contested area of policy, particularly for the risks associated with exposure to radiation. The Committee returns to this matter in chapter 11 where it recommends strategies to improve public understanding in an attempt to dispel irrational fears associated with radiation.

6.292 In the following two chapters the Committee addresses the third objection to the use of nuclear power—nuclear proliferation and the effectiveness of safeguards regimes.

7

The global non-proliferation regime

The non-proliferation regime has been remarkably successful, but has had to respond to challenges over the years, and must continue to do so to remain effective. If such challenges are not met, the expansion of nuclear energy will come to be seen, by governments and the public alike, not as a benefit, but as a risk to international security.[1]

If we, the global community, accept that the benefits of peaceful nuclear technology are essential to our health, our environment, and our social and economic development, then we owe it to ourselves to ensure that we have a framework in place that can effectively prevent the military applications of this technology from leading to our self-destruction.[2]

1 The Hon Alexander Downer MP, *Submission no. 33*, p. 3.

2 Dr Mohamed ElBaradei (IAEA Director General), *Treaty on the Non-Proliferation of Nuclear Weapons*, Address at the 2005 Review Conference of the Treaty on the Non-Proliferation of Nuclear Weapons, 2 May 2005, United Nations, New York, viewed 12 February 2006, <http://www.iaea.org/NewsCenter/Statements/2005/ebsp2005n006.html>.

Key messages —

- **The political commitment of an overwhelming majority of states against proliferation, combined with the institutional and technical safeguards that have been developed over time, have been highly successful in limiting the spread of nuclear weapons to date.**
- **Today, in addition to the five nuclear-armed states that existed prior to the entry into force of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) in 1970, there are only four states that have or are believed to have nuclear weapons: the three non-NPT parties—Israel, India and Pakistan—and North Korea. This is clearly a tremendous achievement, particularly in light of predictions that by the end of the 20th century there would be some 25 to 30 nuclear armed states.**
- **Safeguards are the technical measures used to verify that countries are honouring their commitments under the NPT and other agreements not to use nuclear materials and facilities for nuclear-weapons purposes.**
- **A strengthened safeguards system has now been developed, which is based on Comprehensive Safeguards Agreements entered into by states with the International Atomic Energy Agency (IAEA) and an Additional Protocol (AP) to those agreements, which provides a higher standard for verification of states' nuclear undertakings. The strengthened safeguards system helps to provide assurance not only that declared nuclear material is not diverted for military purposes, but also that there are no undeclared nuclear activities in a state with an AP in force.**
- **Australia played a prominent role in the negotiation of the AP and was the first country to sign and ratify a Protocol. Furthermore, the Australian Government has made the AP a pre-condition for the supply of Australian uranium to non-nuclear weapons states (NNWS).**
- **The IAEA's verification efforts may not be judged fully effective until its access rights, which have been significantly widened under the AP, are evenly applied across states. The AP must become the universal standard for verifying states' nuclear non-prolifertion commitments and the slow adoption of APs to date is disappointing.**

- **Challenges to the non-proliferation regime must be met so that the public can be confident that an expansion of nuclear power and of uranium exports will not represent a risk to international security.**
- **Among these challenges is a weakening of political support for the NPT. Contributing to this situation are two arguments, advanced by some states, that: the NPT guarantees the right of any country to establish the entire nuclear fuel cycle, including the proliferation-sensitive technologies of uranium enrichment and reprocessing; and the argument that the nuclear weapon states (NWS) are not meeting their disarmament obligations under the NPT.**
- **The non-prolifertion core of the NPT may have been neglected as some states have sought to use non-proliferation as a bargaining chip in this false argument between disarmament and nuclear technology acquisition. This is a regrettable political development and the Committee encourages the Australian Government to impress on other countries the central importance of the non-proliferation aspects of the Treaty. Only a stable non-proliferation environment and a firm commitment by all NNWS to non-proliferation will provide the conditions for further reductions in nuclear arsenals. At the same time, the Committee acknowledges the significant reductions in NWS arsenals to date.**
- **Several proposals have recently been made to control the further spread of proliferation-sensitive technologies and to enhance the effectivness of the nuclear verification regime. These include mutilateral approaches to the nuclear fuel cycle, such as multination or regional operation of nuclear facilities and assurances of fuel supply for those countries that forgo development of proliferation-sensitive technologies.**
- **The Committee notes with interest the still nascent proposal by the US Government for a Global Nuclear Energy Partnership (GNEP). GNEP hopes to enable expanded use of nuclear power through the deployment of a fuel cycle that does not require production of separated plutonium, and the use of advanced nuclear reactors in fuel supplier nations which can consume plutonium and much of the waste material.**
- **Australia continues to make a significant contribution to the development of the non-proliferation regime through its advocacy in a wide range of fora.**

Introduction

7.1 In this and the following chapter the Committee addresses the third objection to the use of nuclear power—nuclear proliferation and the effectiveness of safeguards regimes.

7.2 The chapter first introduces the concept of proliferation and explains how some technologies required in the civil nuclear fuel cycle also have military uses. The Committee describes the current global non-proliferation regime, the key elements of which are the Treaty on the Non-Proliferation of Nuclear Weapons and the safeguards activities of the International Atomic Energy Agency (IAEA).

7.3 While submitters acknowledged that improvements have been made to IAEA safeguards in recent years, it was argued that a number of deficiencies remain. These alleged deficiencies and a response to each claim from the Australian Safeguards and Non-Proliferation Office are summarised in turn.

7.4 Finally, the chapter presents an overview of measures recently proposed to address perceived vulnerabilities in the non-proliferation regime. Australia's extensive contribution to the development of the regime is summarised.

7.5 The Committee considers Australia's bilateral safeguards arrangements, which are superimposed on the IAEA safeguards system, and related issues in the following chapter.

Proliferation

7.6 Nuclear proliferation may be understood as the spread of technologies, expertise and materials, that may assist in the production of nuclear weapons, to countries that do not already have such capabilities. 'Horizontal' proliferation refers to an increase in the number of countries that have nuclear weapons production technology, while 'vertical' proliferation refers to an increase in the size or destructive capacity of the nuclear arsenals of those countries that already possess nuclear weapons.[3]

7.7 The requirements to construct nuclear weapons are a sufficient quantity of fissile material of suitable quality, combined with the necessary technical

3 Australian Science and Technology Council (ASTEC), *Australia's Role in the Nuclear Fuel Cycle*, AGPS, Canberra, 1984, p. 98.

capability. The fissile material required to construct nuclear weapons would need to be either very highly enriched uranium, or plutonium (Pu) with a suitable isotopic composition (plutonium relatively rich in the isotope Pu-239).[4] Other technologies are also required for weapon components and the necessary weapon delivery system.

7.8 The Hon Alexander Downer MP, Minister for Foreign Affairs, explained that two technologies used in the civil nuclear fuel cycle are capable of producing weapons useable material, and are thus considered proliferation-sensitive technologies:

> … the technologies used to produce nuclear reactor fuel—uranium enrichment or plutonium separation [for reprocessing of used reactor fuel]—can also be used to produce fissile material for nuclear weapons. The diversion of nuclear material from peaceful uses could also contribute to development of nuclear weapons, although in most cases enrichment or reprocessing capabilities would also be required.[5]

7.9 While most nuclear reactors require uranium enriched to no more than five per cent U-235, or low enriched uranium (LEU), nuclear weapons must have uranium enriched to 90 per cent or more U-235 (the category of highly enriched uranium (HEU) starts at 20 per cent U-235).[6] However, the proliferation risk associated with enrichment is that the same technology used to produce LEU can also be used to produce HEU for use in nuclear weapons.[7]

7.10 In relation to reprocessing, plutonium is formed during normal reactor operations and is contained within the used reactor fuel in a mixture with uranium and fission products. The unused uranium and plutonium can be separated out in a reprocessing plant and then recycled into new reactor fuel. Separated plutonium could be diverted for use in a nuclear weapon. The weapons useability of so-called reactor-grade plutonium is discussed in the following chapter.

7.11 It is thus a principal aim of global non-proliferation efforts to limit the spread of these proliferation-sensitive technologies that could be used to produce fissile material for nuclear weapons—enrichment and reprocessing (plutonium separation):

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4 Australian Safeguards and Non-Proliferation Office, *Exhibit no. 93, Informal briefing concerning the Global Nuclear Energy Partnership*, p. 7.

5 The Hon Alexander Downer MP, *Submission no. 33*, pp. 2–3.

6 Australian Safeguards and Non-Proliferation Office, *Annual Report 2003–2004,* Commonwealth of Australia, Canberra, 2004, p. 107.

7 Medical Association for the Prevention of War (Victorian Branch), *Submission no. 30*, p. 5.

> …because enrichment or reprocessing are indispensable for the production of weapons material, the earliest institutional barrier against proliferation was control over the supply of enrichment and reprocessing technologies, and this remains a key element in the non-proliferation regime. Most States with nuclear power programs have neither enrichment nor reprocessing facilities, instead contracting with others for these services.[8]

The global non-proliferation regime

7.12 Given that technologies used to produce nuclear reactor fuel can also be used to produce fissile material for nuclear weapons, the international community has long recognised that the use of nuclear energy needs to be accompanied by measures to counter proliferation. This has been recognised through 'the ongoing development and refinement of the nuclear non-proliferation regime.'[9]

7.13 The global nuclear non-proliferation regime has evolved into a complex blend of mutually reinforcing elements designed to provide assurance that the peaceful use of nuclear energy does not contribute to the proliferation of nuclear weapons. The key treaty and institutional elements of the regime are the Treaty on the Non-Proliferation of Nuclear Weapons (NPT or 'the Treaty') and the safeguards measures of the International Atomic Energy Agency (IAEA, or 'the Agency').

The Treaty on the Non-Proliferation of Nuclear Weapons

7.14 The Treaty on the Non-Proliferation of Nuclear Weapons, which entered into force in March 1970, is the principal international legal instrument underpinning the global non-proliferation regime. The NPT has three objectives which are to: prevent the spread of nuclear weapons and weapons technology; promote cooperation in the peaceful uses of nuclear energy; and to further the goal of achieving nuclear disarmament, and general and complete disarmament.[10]

7.15 The Treaty currently has some 189 states as parties—the most widely adhered to multilateral disarmament and non-proliferation agreement. States parties include the five nuclear-weapon states (NWS), which were those recognised by the NPT as having nuclear weapons at 1 January 1967

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8 Australian Safeguards and Non-Proliferation Office, *Exhibit no. 93, op. cit., p. 8.*

9 The Hon Alexander Downer MP, *op. cit.*, p. 3.

10 IAEA, *International Conventions & Agreements*, IAEA, Vienna, 2006, viewed 1 August 2006, <http://www.iaea.org/Publications/Documents/Treaties/npt.html>.

when the Treaty was negotiated; namely, the United States, Russia, the United Kingdom, France and China. At the NPT Review and Extension Conference held in May 1995, 25 years after the Treaty's entry into force, states parties made the NPT permanent and decided that review conferences should continue to be held every five years. The most recent review conference was held in May 2005.[11]

7.16 Under the Treaty, the NWS parties have undertaken not to transfer nuclear weapons or nuclear explosive devices to any recipient (Article I) and non-nuclear-weapon states (NNWS) have agreed to forego acquiring or developing nuclear weapons (Article II). The NPT establishes a safeguards system under the responsibility of the IAEA (Article III), described further below, to verify the fulfillment of the NNWS obligations under Article II. The Treaty affirms the right of all parties to use nuclear energy for peaceful purposes and to participate in the exchange of equipment, materials and information for the peaceful uses of nuclear energy (Article IV). All parties are committed to pursue nuclear and general disarmament (Article VI).[12]

7.17 Other treaties and agreements that contribute to achieving non-proliferation objectives include:

- nuclear-weapon-free zone treaties in Latin America (Tlatelolco Treaty), the South Pacific (Rarotonga Treaty), Southeast Asia (Bangkok Treaty) and Africa (Pelindaba Treaty);
- the treaty establishing the European Atomic Energy Community (Euratom); and
- the Agreement between the Republic of Argentina and the Federative Republic of Brazil for the Exclusively Peaceful Use of Nuclear Energy (Guadalajara Declaration).[13]

International Atomic Energy Agency

7.18 The key institutional element of the global non-proliferation regime is the IAEA and its technical measures, or safeguards activities, for verifying that countries are honouring their commitments under the NPT and other

11 IAEA, *Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons*, IAEA, Vienna, 2004, p. 1, viewed 1 August 2006, <http://www.un.org/events/npt2005/presskit.pdf>.

12 IAEA, *Treaty on the Non-Proliferation of Nuclear Weapons,* IAEA Information Circular 140 (INFCIRC/140), viewed 1 August 2006, <http://www.iaea.org/Publications/Documents/Infcircs/Others/infcirc140.pdf>.

13 IAEA, *IAEA Safeguards Glossary*, IAEA, Vienna, 2001, pp. 2–5, viewed 1 August 2006, <http://www-pub.iaea.org/MTCD/publications/PDF/nvs-3-cd/Start.pdf>.

treaties not to use nuclear materials and facilities for nuclear-weapons purposes.[14]

7.19 The Statute of the IAEA, which came into force in July 1957, states that the objective of the IAEA is:

> … to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world. It shall ensure, so far as it is able, that assistance provided by it or at its request or under its supervision or control is not used in such a way as to further any military purpose.[15]

7.20 Established as an autonomous organistion under the aegis of the United Nations, the IAEA seeks to achieve its objective through three areas of work:

- promoting nuclear science and technology, particularly for the benefit of developing countries, through research and development (R&D) into practical applications of atomic energy for peaceful uses, promoting the exchange of scientific and technical information between member states, and transferring nuclear science and technology through technical cooperation programs;
- verifying, through its safeguards program, that nuclear materials subject to safeguards are not diverted to nuclear weapons; and
- enhancing the safety and security of nuclear material and facilities as well as of other radioactive materials.[16]

7.21 The objective of safeguards is to detect, in a timely manner, diversion of 'significant quantities' of nuclear material from peaceful nuclear activities to the manufacture of weapons or other explosive devices, and to deter such diversions by the risk of early detection.[17]

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14 ASTEC, *op. cit*., p. 108. In addition to the IAEA, Areva also pointed to the existence of other regional safeguards and verfication organisations such as EURATOM and ABACC. Areva, *Submission no. 39*, p. 8. EURATOM is organisation comprised of the European Atomic Energy Community. ABACC is the Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials. ABACC is a binational agency created by the governments of Brazil and Argentina, responsible for verifying the pacific use of nuclear materials that could be used, either directly or indirectly, for the manufacture of weapons of mass destruction.

15 IAEA, *Statute of the IAEA*, IAEA, Vienna, 1956, viewed 13 July 2006, <http://www.iaea.org/About/statute_text.html#A1.3>.

16 See: IAEA, *Annual Report 2004*, IAEA, Vienna, 2005, viewed 3 August 2006, <http://www.iaea.org/Publications/Reports/Anrep2004/index.html>. The functions of the IAEA are listed in Article III of the IAEA's Statute.

17 A 'significant quantity' (SQ) is the approximate quantity of any given type of nuclear material, which, taking into account any conversion process involved is required for the manufacture of a nuclear explosive device. For example, the SQ for plutonium is 8 kg of Pu containing less than 80 per cent Pu-238. See: IAEA, *IAEA Safeguards Glossary*, *op. cit*., p. 23; ASNO, *Submission no. 33.2*, p. 6.

7.22 The IAEA safeguards system is based on assessment of the correctness and completeness of a state's declared nuclear material and activities. Currently, 156 states have safeguards agreements in force with the IAEA and more than 900 nuclear facilities in 71 countries are under routine safeguards inspection.[18]

7.23 The NPT requires NNWS parties to conclude comprehensive safeguards agreements (CSAs) with the IAEA, and thus allow for the application of safeguards to all of their nuclear material ('source or special fissionable material') in all nuclear activities.[19] CSAs are also required by the nuclear-weapon-free zone treaties listed in the preceding section. Article III of the NPT provides that all of the NNWS must:

> … accept safeguards, as set forth in an agreement to be negotiated and concluded with the International Atomic Energy Agency for the exclusive pupose of verification of the fulfillment of its obligations assumed under [the NPT] with a view to preventing diversion of nuclear energy from peaceful uses to nuclear weapons or other explosive devices.[20]

7.24 The five NPT NWS parties have concluded a second type of safeguards agreement, referred to as Voluntary Offer Agreements (VOAs), covering some or all of their peaceful nuclear activities. Under VOAs, facilities or nuclear materials in facilities notified to the IAEA are offered for the application of safeguards.[21]

7.25 A third type of safeguards agreement is known as Item-Specific safeguards agreements. The three non-NPT parties, India, Pakistan and Israel, have entered into these agreements which cover only specified material, facilities and other items of equipment or non-nuclear material. States parties to these agreements undertake not to use the material or

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18 IAEA, *IAEA Safeguards: Stemming the Spread of Nuclear Weapons*, IAEA, Vienna, 2002, p. 1, viewed 2 August 2005, <http://www.iaea.org/Publications/Factsheets/English/S1_Safeguards.pdf>; IAEA, *Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons*, IAEA, Vienna, 2005, p. 3, viewed 3 August 2006, <http://www.un.org/events/npt2005/presskit.pdf>.

19 Source material is defined in the IAEA's Statute as uranium containing the mixture of isotopes occurring in nature, uranium depleted in the isotope 235 and thorium. Special fissionable material is defined as plutonium-239, uranium-233, and uranium enriched in the isotopes 235 or 233. See: IAEA, *Statute of the IAEA,* Article XX: Definitions, *loc. cit.*

20 IAEA, *Treaty on the Non-Proliferation of Nuclear Weapons, loc. cit.* For an overview of the safeguards system see: IAEA, *The Safeguards System of the International Atomic Energy Agency*, IAEA, Vienna, viewed 1 August 2006, <http://www.iaea.org/OurWork/SV/Safeguards/safeg_system.pdf>.

21 IAEA, *Annual Report 2004*, *op. cit.*, p. 62, viewed 2 August 2006, <http://www.iaea.org/Publications/Reports/Anrep2004/safeguards.pdf>.

facilities under safeguards in such a way as to further any military purpose.[22]

7.26 Once a safeguards agreement has entered into force, the state concerned has an obligation to declare to the IAEA all nuclear material and facilities subject to safeguards under the agreement, and to update this information as circumstances change. The IAEA's basic measures for safeguarding the declared nuclear material and facilities are:

- nuclear material accounting, through which, on the basis of information provided primarily by the state concerned, the IAEA establishes an initial inventory of nuclear material in the state, and records subsequent changes to it;
- containment and surveillance measures to monitor access to and movement of nuclear material; and
- on-site inspections (which are of three types: ad hoc, routine or special) and safeguards visits during which IAEA inspectors have the right to carry out a variety of measures (such as verifying facility design information, examining records, taking measurements and samples of nuclear material for IAEA analysis, verifying the functioning and calibration of instruments and installing surveillance equipment) for the purpose of verifying the correctness and completeness of states' declarations concerning nuclear materials accountancy and their nuclear programs.[23]

7.27 The IAEA notes that although safeguards developed progressively since their inception, until recently the IAEA system focussed mainly on nuclear material and activities declared by the state concerned. However, the discovery of Iraq's clandestine nuclear weapons program, despite an existing CSA between the IAEA and Iraq, and subsequent events in the Democratic People's Republic of Korea (DPRK, or North Korea), demonstrated that an effective verification regime must also focus on possible *undeclared* materials and activities.

7.28 Following the Iraqi revelations, the IAEA's Board of Governors agreed that the traditional safeguards system would henceforth have to provide assurance not only of the non-diversion of declared nuclear material, but also of the absence of any undeclared nuclear material and activities. Consequently, in 1992, the IAEA began to introduce safeguards strengthening measures which provided extended mechanisms for

22 IAEA, *Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons, op. cit.*, p. 2.

23 *ibid*. See also: IAEA, *IAEA Safeguards Overview: Comprehensive Safeguards Agreements and Additional Protocols*, IAEA, Vienna, 2004, viewed 29 September 2005, <http://www.iaea.org/Publications/Factsheets/English/sg_overview.html>.

verification. These measures focussed on obtaining more information from states about their nuclear material, facilities and plans, on gaining more access to locations at which nuclear material is or could be present, and on using new verification technology.[24]

7.29 It was found that some measures to strengthen the safeguards system required additional legal authority and in May 1997 the IAEA Board of Governors approved a Model Additional Protocol to Safeguards Agreements which contains a number of provisions conferring upon the IAEA the legal authority to implement further strengthening measures.

7.30 Under an Additional Protocol (AP), a state is required to provide the IAEA with broader information covering all aspects of its nuclear fuel cycle-related activities, including R&D and uranium mining. States must also grant the Agency broader access rights ('complementary access') and enable it to use the most advanced verification technologies. Specific measures provided for in an AP include:

- information about, and access to, all aspects of states' nuclear fuel cycle, from uranium mines to nuclear waste and any other locations where nuclear material intended for non-nuclear uses is present;
- short-notice inspector access to all buildings on a nuclear site;
- information on the manufacture and export of sensitive nuclear-related technologies and inspection mechanisms for manufacturing and import locations;
- access to other nuclear-related locations; and
- collection of environmental samples beyond declared locations when deemed necessary by the IAEA.[25]

7.31 The IAEA maintains that with wider access, broader information and better use of technology, the Agency's capability to detect and deter undeclared nuclear material or activities is now significantly improved.[26]

7.32 Each country has been asked by the IAEA to conclude an AP to complement its existing safeguards agreement and the IAEA believes that CSAs and an AP are fast becoming the contemporary standard for NPT safeguards worldwide. However, the Australian Safeguards and Non-Proliferation Office (ASNO) noted that uptake of APs remains disappointing. As of January 2006, some 60 per cent of NPT parties had ratified or signed a Protocol. However, in terms of actual safeguards

24 IAEA, *Non-Proliferation of Nuclear Weapons and Nuclear Security*, IAEA, Vienna, May 2005, p. 6, viewed 2 August 2006, <http://www.iaea.org/Publications/Booklets/engl_nuke.pdf>.

25 IAEA, *IAEA Safeguards: Stemming the Spread of Nuclear Weapons*, *op. cit.*, p. 3; IAEA, *IAEA Safeguards Overview: Comprehensive Safeguards Agreements and Additional Protocols*, *loc. cit.*

26 *ibid.*

implementation, the situation is more positive. More than 85 per cent of the NNWS that are party to the NPT and have significant nuclear activities (55 out of 63 states) have ratified or signed an AP.[27] As of 14 July 2006, 110 states and other parties had signed APs and 77 had APs in force.[28]

7.33 Minister Downer noted that Australia played a prominent role in the negotiation of the AP and Australia was the first country to sign and ratify a Protocol. Furthermore, at the 2005 NPT Review Conference the Minister announced that Australia would make the AP a pre-condition for the supply of Australian uranium to NNWS.[29]

7.34 In terms of the scope of IAEA safeguards, under CSAs the starting point in the nuclear fuel cycle for the application of safeguards begins when nuclear material suitable for enrichment leaves conversion plants. However, when a state exports to a NNWS they are also required to report exports, or imports, of any material containing uranium or thorium, unless it is transferred for specifically non-nuclear purposes. Furthermore, under APs, states are required to provide the IAEA with information on uranium and thorium prior to conversion and this information is to be provided both on such material present in the state, whether in nuclear or non-nuclear use, and on exports and imports of such material for specifically non-nuclear purposes. Safeguards terminate when nuclear material has been consumed or has been diluted in such a way as to be no longer usable for weapons purposes, or has become practically irrecoverable.[30]

7.35 The IAEA reports annually on safeguards implementation to the Agency's Board of Governors, including any violations by a state of its safeguards agreement with the IAEA (i.e. non-compliance). In the Safeguards Statement for 2005 the IAEA reported its safeguards conclusions with regard to each type of safeguard agreement, as follows.

- Seventy states had both CSAs and APs in force or otherwise being applied:
  - ⇒ For 24 of these states, the Agency found no indication of the diversion of declared nuclear material from peaceful activities and no indication of undeclared nuclear material or activities. On this basis, the Agency concluded that, for these states, all nuclear material remained in peaceful activities.

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27 The Hon Alexander Downer MP, *Submission no. 33.2*, p. 7.

28 IAEA, *Strengthened Safeguards System: Status of Additional Protocols*, IAEA, Vienna, 2006, viewed 2August 2006, <http://www.iaea.org/OurWork/SV/Safeguards/sg_protocol.html>; IAEA, *Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons, op. cit.*, p. 3.

29 The Hon Alexander Downer MP, *loc. cit.*

30 IAEA, *IAEA Safeguards Glossary*, *op. cit.*, pp. 16–17.

⇒ For 46 of the states, the Agency found no indication of the diversion of declared nuclear material, while evaluations regarding the absence of undeclared nuclear material and activities for these states remained ongoing. On this basis, the Agency only concluded that, for these states, declared nuclear material remained in peaceful activities.

- Seventy-seven states had CSAs in force but without APs, and for these states the Agency found no indication of the diversion of declared nuclear material from peaceful nuclear activities. It was concluded that declared nuclear material remained in peaceful activities in these states.
- At the end of 2005, 36 NNWS parties to the NPT had not yet brought CSAs with the IAEA into force. For these states the Agency could not draw any safeguards conclusions.[31]
- Three states had Item-Specific safeguards agreements in force and the Agency found no indication of the diversion of nuclear material or of the misuse of the facilities to which safeguards were applied. On this basis, the Agency concluded that, for these states, nuclear material, facilities or other items to which safeguards were applied remained in peaceful activities.
- Five NWS had VOAs in force and safeguards were implemented with regard to declared nuclear material in selected facilities in four of the five states (UK, US, France and China). For these four states, the Agency found no indication of the diversion of nuclear material to which safeguards were applied and concluded that these materials remained in peaceful activities.[32]

7.36 The IAEA reported that since December 2002, when the DPRK terminated the Agency's safeguards activities in the country, the Agency has not been able to perform any verification activities in the DPRK. The Agency is therefore unable to draw any conclusions about North Korea's nuclear materials or activities.[33] The DPRK, which has had a CSA in force with the IAEA since 1992, has stated that it now has a nuclear weapons capability.[34] In October 2006 the DPRK claimed to have conducted a nuclear weapons test.

31 As of 14 July 2006, there were 32 NNWS that had still to bring CSAs into force. See: IAEA, *NPT Comprehensive Safeguards Agreement Overview of Status,* IAEA, Vienna, 14 July 2006, viewed 1 August 2006, <http://www.iaea.org/Publications/Factsheets/English/nptstatus_overview.html>

32 IAEA, *Safeguards Statement for 2005*, IAEA, Vienna, 2005, pp. 1–2, viewed 1 August 2006, <http://www.iaea.org/OurWork/SV/Safeguards/es2005.html>.

33 *ibid*., p. 9.

34 IAEA, A*nnual Report 2004*, IAEA, Vienna, 2005, p. 63, viewed 2 August 2006, <http://www.iaea.org/Publications/Reports/Anrep2004/safeguards.pdf>.

7.37 Iran has had a CSA in force with the IAEA since 1974 and in December 2003 it signed, but did not subsequently ratify, an AP. The 2005 Safeguards Statement reported that Iran had been found to have previously engaged in undeclared nuclear activities. The IAEA Board of Governors found that Iran's 'many failures and breaches of its obligations' to comply with its CSA constituted non-compliance.[35]

7.38 In particular, it was found that Iran has been conducting R&D into enrichment and plutonium separation, without reporting these activities to the IAEA, for some 20 years. It has therefore failed to meet its obligations under its CSA and the NPT. The IAEA has also consistently reported a lack of adequate transparency and cooperation on the part of Iran. ASNO noted that:

> Iran argues that it needs to be self sufficient in the nuclear fuel cycle to support a nuclear power program. However, the extent and timing of Iran's activities, the covert nature of the program, its links to illicit procurement networks, and the lack of an economic rationale for developing uranium enrichment are inconsistent with a peaceful civil nuclear power industry.[36]

7.39 Furthermore, ASNO noted that Iran does not actually have a nuclear power program (it has only one reactor under construction) and Russia, which is building the reactor in question, has undertaken to supply fuel for 30 years.[37]

7.40 At the end of 2005 there remained two issues of relevance to the IAEA's verification efforts in Iran: the origin of low enriched uranium and high enriched uranium particle contamination found at various locations in Iran; and the extent and nature of Iran's enrichment program.[38]

7.41 In recent developments, on 31 July 2006 the UN Security Council demanded, in Resolution 1696, that Iran suspend all enrichment-related and reprocessing activities by 31 August 2006. The Resolution stated that if Iran failed to comply it may be subjected to economic and diplomatic sanctions. The Resolution noted the Security Council's serious concerns, including: the series of reports and resolutions by the IAEA's Board of Governors on Iran's nuclear program; that after three years of IAEA verification efforts to clarify all aspects of Iran's nuclear program the Agency is still unable to provide assurances about Iran's undeclared nuclear material and activities; that Iran has resumed enrichment-related

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35 IAEA, *Safeguards Statement for 2005*, *op. cit.*, pp. 8–9.

36 ASNO, *Annual Report 2004–2005*, Commonwealth of Australia, Canberra, 2005, p. 13.

37 The Hon Alexander Downer MP, *Submission no. 33.2*, p. 3.

38 IAEA, *Safeguards Statement for 2005*, *loc. cit.*

activities contrary to requirements by the IAEA; and its continued suspension of cooperation with the IAEA under the AP.[39]

7.42 The IAEA was requested to report back to the Security Council by 31 August on Iran's compliance with its demands as well as on Iran's compliance with steps required by the IAEA's Board of Governors. Iran rejected the suspension deadline.[40]

7.43 IAEA safeguards inspectors conduct over 2 000 inspections at over 600 facilities world-wide each year. Inspectors analyse some 880 environmental swipe samples and verify that hundreds of tonnes of special fissile material remains in peaceful use.[41] The IAEA's annual Safeguards Statement reports on the Agency's field activities during the previous year. For example, during 2005 safeguards inspectors carried out 1 700 inspections and 160 complementary accesses utilising some 11 300 calendar-days in the field for verification in states with CSAs and APs in force or otherwise applied.[42]

7.44 The 2005 Safeguards Statement notes that the IAEA's safeguards expenditure from the Program's regular budget amounted to US$130 million. An additional $12.9 million was spent from voluntary contributions from member states.[43]

7.45 In 1998 the IAEA commenced a program for the development of 'integrated safeguards', which refers to the optimum combination of all safeguards measures available to the IAEA under CSAs and APs, which is said to achieve maximum effectiveness and efficiency within available resources. In 2005 integrated safeguards were implemented in Australia, Hungary, Indonesia, Japan, Norway, Peru, and Uzbekistan.[44]

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39 UN Security Council, *Non-proliferation*, UN Security Council Resolution 1696 (2006), viewed 3 August 2006, <http://daccessdds.un.org/doc/UNDOC/GEN/N06/450/22/PDF/N0645022.pdf?OpenElement>.

40 See for example: A K Dareini, 'Iranian President Rejects Nuke Deadline', *The Guardian*, 1 August 2006, viewed 3 August 2006, <http://www.guardian.co.uk/worldlatest/story/0,,-5987979,00.html>.

41 IAEA, *IAEA Verification Activities at a Glance*, IAEA, Vienna, 2004, viewed 1 August 2006, <http://www.iaea.org/NewsCenter/Focus/Npt/activities_glance.shtml>.

42 See: IAEA, *Safeguards Statement for 2005*, *op. cit.*, pp. 4, 6, 7, 8.

43 *ibid.*, p. 10.

44 *ibid.*, p. 9; IAEA, *Non-Proliferation of Nuclear Weapons and Nuclear Security*, *op. cit.*, p. 7; IAEA, *Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons*, *loc. cit.*

Other elements of the non-proliferation regime

7.46 In addition to the NPT and safeguards measures of the IAEA, there are a range of complementary measures which support the global non-proliferation regime, such as national policies on nuclear supply and multilateral efforts to control the export of sensitive technologies, materials and equipment. These measures include, but are not limited to, the following:

- Nuclear Suppliers' Group (NSG) Guidelines—The NSG is a group of 45 nuclear supplier countries which seeks to contribute to the non-proliferation of nuclear weapons through the implementation of Guidelines for export controls on nuclear and nuclear-related material, equipment, software and technology, without hindering international cooperation on peaceful uses of nuclear energy.[45]
- Proliferation Security Initiative (PSI)—The PSI is an international counter proliferation effort, initiated by the US Government in 2003, which applies intelligence, diplomatic, law enforcement, military, and other tools to prevent transfers of weapons of mass destruction (WMDs), their delivery systems, and related materials to states and non-state actors of proliferation concern. Over 70 countries now support the PSI.[46]
- UN Security Council Resolution 1540—Adopted by the Security Council in April 2004, Resolution 1540 calls on all states to, inter alia, refrain from providing any form of support to non-state actors that attempt to obtain WMDs and to enforce appropriate domestic laws, take and enforce measures to establish domestic controls to prevent proliferation of WMDs, and take cooperative action to prevent illicit trafficking in such weapons.[47]
- G8 Action Plan on Non-Proliferation—In June 2004 the G8 group of nations agreed to a package of non-proliferation measures, which included, inter alia, a one-year freeze on any new initiatives to transfer

45 Nuclear Suppliers' Group web site, viewed 2 August 2006, <http://www.nuclearsuppliersgroup.org/>. A statement issued by the NSG following its most recent Plenary Meeting is available at: <http://www.nuclearsuppliersgroup.org/PRESS/2006-07-Brasilia.pdf>.

46 Information on the PSI available on the US Department of State web site, viewed 2 August 2006, <http://www.state.gov/t/np/rls/other/46858.htm>. See also: The Hon Alexander Downer MP, *Submission no. 33.4*, p. 2; Dr Michael Goldsworthy (Silex Systems Ltd), *Transcript of Evidence*, 9 February 2006, p. 5.

47 UN Security Council, *Non-proliferation of weapons of mass destruction*, UN Security Council Resolution 1540 (2004), viewed 2 August 2006, <http://daccessdds.un.org/doc/UNDOC/GEN/N04/328/43/PDF/N0432843.pdf?OpenElement>

enrichment and reprocessing technology to additional states pending possible further amendments to NSG Guidelines. The Action Plan foreshadowed developing new measures to ensure reliable access to nuclear materials, equipment and technology, including nuclear fuel and related services for all states, consistent with maintaining non-proliferation commitments. The G8 also called for universal adherence to IAEA comprehensive safeguards and the AP.[48]

Dual use technologies and the link between civil and military nuclear programs

7.47 The principal criticism of nuclear power, on proliferation grounds, is that civil nuclear programs and weapons programs are said to be 'inextricably linked' because of the 'dual use' technologies of uranium enrichment and reprocessing outlined above. For example:

- The Darwin NO-WAR Committee submitted that there is 'an inextricable link between nuclear power and nuclear weapons'.[49]
- Mr Justin Tutty argued that: 'Ever since the development of the first nuclear reactors in the 1950s, nuclear power has been inextricably linked to the spectre of nuclear weapons.'[50]
- The Medical Association for the Prevention of War (MAPW) (WA Branch) argued that:

> The technical link between nuclear power and nuclear weapons remains the strongest argument against … nuclear power plants so long as the current climate of mistrust and terrorist activity is compounded by the failure of the nuclear capable states to agree on a program to dismantle their weapons.[51]

- The Australian Conservation Foundation (ACF) argued that:

> The nuclear industry is fundamentally 'dual use' across nuclear power capacity and nuclear weapons capabilities. Nuclear power programs provide technology, facilities, experience, skills, nuclear materials and a cover for many countries holding and developing threshold nuclear weapons potential. Australia's role as uranium fuel supplier to the world nuclear industry is inseparable from this dual use reality.[52]

48 *G8 Action Plan on Non-Proliferation*, available on the White House web site, viewed 2 August 2006, <http://www.whitehouse.gov/news/releases/2004/06/20040609-28.html>.

49 Darwin NO-WAR Committee, *Submission no. 13*, p. 1

50 Mr Justin Tutty, *Submission no. 41*, p. 2.

51 Dr Stephen Masters (MAPW – WA Branch), *Transcript of Evidence*, 23 September 2005, p. 37.

52 ACF, *Submission no. 48*, p. 9.

- The MAPW (Victorian Branch) concluded that:

> … nuclear power pose[s] an unacceptable threat to human health, primarily because of the inextricable nexus between the expertise, technology and materials required to fuel nuclear power reactors and those required to produce nuclear bombs. Uranium mining underpins both nuclear reactors and nuclear bombs.[53]

7.48 Based on the belief that the danger of nuclear war is the greatest immediate threat to the health and survival of humankind, the MAPW (Victorian Branch), ACF and others expressed opposition to all exports of uranium, and the nuclear power industry as a whole, because 'there is an inevitable association between nuclear power generation and proliferation, and terrorist and other unacceptable health and environmental risks.'[54] The MAPW (Victorian Branch) were convinced that it is not possible to achieve a nuclear weapons-free world while nuclear power is used to generate a substantial proportion of world electricity.

7.49 Similarly, the MAPW (WA Branch) and others opposed further uranium mining on the basis that to increase uranium production will, allegedly, inevitably lead to an increase in the global stocks of fissile material, such as civil plutonium stockpiles, and thereby increase the risk of diversion into weapons programs.[55] However, MAPW (WA Branch) subsequently conceded that it 'could certainly envisage a time' when, if proliferation dangers were addressed, 'we could get nuclear power going and avoid most of the problems.'[56]

7.50 Some submitters also argued that civil nuclear programs have been used to support weapons programs, including in the five NWS. For instance, Friends of the Earth–Australia (FOE) argued that:

> It is … a matter of historical record that of the 60 countries which have developed a nuclear industry to any significant extent, including a power and/or research reactor, over 20 of those countries have used their supposedly peaceful nuclear facilities and materials for weapons research and/or production.[57]

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53 MAPW (Victorian Branch), *op. cit.*, p. 2. See also: Mr Colin Mitchell, *Submission no. 67*, p. 1.

54 Associate Professor Tilman Ruff (MAPW), *Transcript of Evidence*, 19 August 2005, p. 29; MAPW (Victorian Branch), *op. cit.*, p. 4; ACF, *op. cit.*, p. 10.

55 MAPW (WA Branch), *Submission no. 8*, p. 5. See also: Mr W Lewis, *Submission no. 65*, p. 1; Darwin NO-WAR Committee, *loc. cit.*

56 Dr Stephen Masters, *op. cit.*, p. 45.

57 Dr Jim Green (FOE), *Transcript of Evidence*, 19 August 2005, p. 61; FOE, *Submission no. 52*, p. 17; MAPW (Victorian Branch), *op. cit.*, p. 6.

7.51 More specifically, FOE claimed that ostensibly civil nuclear programs preceded and facilitated the successful development of nuclear weapons in India, Pakistan, and in the former nuclear weapons state South Africa.[58]

7.52 ASNO submitted that nuclear weapons programs have been supported by nuclear facilities that have included research reactors, citing India as an example.[59] It was also conceded that those countries that have pursued nuclear weapons have used scientists and engineers who have gained experience in nuclear research programs.[60] However, ASNO argued that, in the history of nuclear weapons programs, those countries with nuclear weapons developed them before they developed nuclear power programs and in some of the countries having nuclear weapons, nuclear power remains insignificant or non-existent:

- in the recognised nuclear-weapon states—US, Russia, UK, France and China—all of these states had nuclear weapons before they developed nuclear power programs;
- in those states found to be in non-compliance with their safeguards agreements—Romania, Iraq, DPRK, Libya and Iran—none of these had nuclear power at the time of the non-compliance, and only Romania has nuclear power now. Iran has a power reactor under construction (by Russia), but this reactor was not part of Iran's clandestine nuclear program; and
- in the three non-NPT states with nuclear weapons, Israel does not have a nuclear power program.[61]

7.53 In making the argument about civil nuclear programs preceding and facilitating development of nuclear weapons, FOE cited India, Pakistan and South Africa, as noted above. However, ASNO responded that:

- India completed its first power reactor, Tarapur 1, in 1969, and conducted its first nuclear explosion in 1974. However, the plutonium for this explosion was produced using the Cirus research reactor, which commenced operation in 1960. India's preparations to acquire a nuclear explosive capability pre-date the Tarapur power reactor by many years;
- Pakistan completed its KANUPP power reactor about the same time as the development of its uranium enrichment program. Pakistan's nuclear weapons program was based on HEU, while the KANUPP reactor operates on natural uranium. There is allegedly no connection between this reactor and the enrichment program; and

58 FOE, *Submission no. 52.1*, p. 3.
59 The Hon Alexander Downer MP, *Submission no. 33.1*, p. 3.
60 *ibid.*, p. 12.
61 *ibid.*, p. 3.

- in South Africa's case, the first stages of the Valindaba vortex enrichment plant to produce HEU were commissioned in 1974, and the first nuclear weapon was produced in 1979. This was well ahead of the commissioning of South Africa's first power reactor at Koeberg, in 1984.[62]

7.54 In summary, ASNO argued emphatically that:

> The examples pointed to by FOE do not substantiate their claim that nuclear power programs support military programs. Currently there are 30 countries, plus Taiwan, operating nuclear power reactors. The overwhelming majority — 24 of the 31 — do not have nuclear weapons. The remaining seven comprise the five nuclear-weapon states and India and Pakistan.[63]

7.55 FOE argued that there would almost certainly be fewer nuclear weapon states in the world today if not for civil nuclear power. The reason given for this was that the non-declared weapon states would not have been able to 'ride their weapons programs on an ostensibly civil program'.[64] In contrast, Mr Ian Hore-Lacy, General Manager of the Uranium Information Centre (UIC), argued that:

> I disagree. I think there would probably be two or three times as many weapons states now if there were no civil nuclear power, because the Nuclear Non-Proliferation Treaty has had this trade-off of technical assistance for the development of civil power on the basis that people stood back from the possibility, and eschewed the possibility, of developing weapons. In the 1960s there were a number of reputable estimates that by the turn of the century there would be at least 30, probably 35, nuclear weapons states. Now we have five official ones, we have three unofficial ones … I think that is an extraordinarily good result.[65]

The effectiveness of the non-proliferation regime

7.56 Evidence to the Committee on the effectiveness of the non-proliferation regime was sharply divided. ASNO argued that although the non-proliferation regime has recently come under serious challenge, to date the regime has been highly successful:

62 *ibid*.

63 *ibid*., p. 4.

64 Dr Jim Green (FOE), *op. cit*., p. 72.

65 Mr Ian Hore-Lacy, *Transcript of Evidence*, 19 August 2005, pp. 93–94.

> In the 1960s it was thought the proliferation of nuclear weapons was inevitable, and it was predicted there would be some 25 to 30 nuclear armed states before the end of the 20th century. Since its conclusion in 1968, the NPT has helped to establish conditions under which proliferation, while not stopped, has been substantially slowed. Today, in addition to the five nuclear-armed states that existed then — the United States, Russia, the United Kingdom, France and China — there are only four that have or are believed to have nuclear weapons: the three non-NPT parties — India, Israel and Pakistan — and the DPRK.[66]

7.57 ASNO credited the success of the regime to the political commitment of the overwhelming majority of states not to acquire nuclear weapons. This political commitment has been reinforced by treaty commitments, particularly membership of the NPT, and further reinforced by confidence-building measures, of which the most important are IAEA safeguards that provide assurance through verification.[67]

7.58 The UIC also argued that:

> International nuclear safeguards have been an outstanding success story in the UN context. With the wisdom of hindsight, they might have been more ambitious when they came into effect in 1970, but the deficiencies - related to undeclared nuclear activities rather than simply traded fissile materials - have been addressed in the 1990s through the Additional Protocol which countries are encouraged to sign and ratify supplementary to their agreements with IAEA.[68]

7.59 Similarly, the Association of Mining and Exploration Companies (AMEC) argued that the international safeguards and other non-proliferation measures have 'arguably been the United Nation's most conspicuous success.'[69]

7.60 In sharp contrast, the ACF argued that the non-proliferation regime, 'including the Non-Proliferation Treaty, have failed to deliver on the key strategic requirement to prevent proliferation of nuclear weapons capabilities.'[70] It was also asserted that:

> Australians have been misled … by claims that IAEA and Australian (ASNO) nuclear safeguards could provide assurance

66 ASNO, *Annual Report 2004–2005*, *op. cit.*, p. 8.

67 ASNO, *Exhibit no. 93, loc. cit.*

68 UIC, *Submission no. 12*, p. 32; Mr Ian Hore-Lacy, *op. cit.*, p. 93;

69 AMEC, *Submission no. 20*, p. 5.

70 ACF, *op. cit.*, p. 9.

> against civilian nuclear programs contributing to military nuclear capabilities and programs.[71]

7.61 In a similar vein, the MAPW (Victorian Branch) asserted that 'it is widely acknowledged that IAEA safeguards, even with the Additional Protocol are inadequate.'[72] FOE added that the 'safeguards system was exposed as a farce' by the clandestine weapons program of the Iraqi regime and that the strengthened safeguards system is still inadequate.[73]

7.62 ASNO disagreed strongly with this view, arguing that current proliferation challenges do not show the break-down of the NPT. While it was a serious concern that some NNWS have attempted to pursue weapons, ASNO argued that this does *not* demonstrate a 'failure' of the NPT:

> The NPT cannot 'prevent' proliferation, any more than national laws can prevent crime. The NPT establishes a standard of behaviour, together with an objective mechanism — IAEA safeguards — for identifying non-compliance and a process for dealing with non-compliance … It is precisely because of the possibility of non-compliance that the Treaty includes a verification mechanism … In this respect, international law is little different to domestic law—when a crime is committed no-one calls for the scrapping of the criminal law on the basis that it is not working, but rather, for more effective law enforcement.[74]

Alleged deficiencies in the non-proliferation regime

7.63 While it was conceded that improvements have been made to the IAEA's safeguards system in recent years, some submitters argued that these still 'face major problems, limitations and contradictions'.[75] It was argued that the IAEA's Strengthened Safeguards Program, which incorporates APs, does not address some of the 'fundamental problems and contradictions of the NPT/IAEA system.'[76]

7.64 Nine specific limitations to the non-proliferation regime were mentioned in evidence submitted by, among others, FOE, MAPW and the AMP

71 *ibid.*
72 MAPW (Victorian Branch), *op. cit.*, p. 3.
73 FOE, *Submission no. 52.1*, p. 3.
74 ASNO, *Annual Report 2004–2005*, *op. cit.*, p. 10.
75 FOE, *Submission no. 52*, p. 18.
76 *ibid.*

Capital Investors Sustainable Funds Team (AMP CISFT).[77] The alleged deficiencies of the regime are that:

- some NPT signatory states have pursued covert weapons programs under cover of the Treaty, and civil nuclear programs have facilitated covert weapons programs;
- NPT states could acquire proliferation-sensitive technologies, as is their right under Article IV of the NPT, then withdraw from the Treaty and pursue weapons programs;
- Nuclear Weapon States are in breach of their disarmament obligations under Article VI of the NPT;
- the IAEA's dual role of promoting the peaceful uses of nuclear energy while preventing weapons proliferation is inconsistent and contradictory;
- membership of the IAEA's Board of Governors is inappropriately weighted;
- timeliness in detecting the diversion of fissile material is problematic;
- nuclear 'Material Unaccounted For' could be diverted for military purposes;
- resource constraints on the IAEA's safeguards activities undermine its effectiveness; and
- safeguards are, in any case, of no relevance to non-NPT states.

7.65 These claims are summarised in the sections which follow. ASNO provided responses to each these alleged deficiencies in the non-proliferation regime, which are also included in the discussion of each issue.

Some NPT signatory states have pursued covert weapons programs and civil nuclear programs have facilitated covert weapons programs

7.66 MAPW and FOE argued that civil programs can provide the expertise, facilities and materials to pursue weapons programs which may be conducted covertly and illegally under cover of the NPT. Civil nuclear programs are said to have facilitated covert weapons programs in countries that were, at various times, in good standing with the NPT such as Iraq, North Korea and Iran. At least eight NPT member states are said to have carried out weapons-related projects in violation of their NPT agreements, or carried out permissible weapons-related activities but

77 See: FOE, *Submission no. 52*, pp. 18–19; FOE, *Submission no. 52.2*, pp. 1–13; Professor Richard Broinowski, *Submission no. 72*, p. 3; MAPW (Victorian Branch), *Submission no. 30*, pp. 3–4; AMP CISFT, *Submission no. 60*, pp. 5–6.

failed to meet their reporting requirements to the IAEA. These countries were said to be: Egypt, Iraq, Romania, Taiwan, Libya, Yugoslavia, DPRK and the Republic of Korea (ROK or South Korea).[78] FOE made specific mention of the ROK, which it was argued conducted a series of 'illicit and/or unreported nuclear weapons research activities' in the 1980s.[79]

7.67 ASNO responded that five countries—Romania, Iraq, DPRK, Libya and now Iran—have been found in non-compliance with their safeguards agreements and have been reported to the Security Council. None of these cases involved countries eligible to use Australian uranium and none of the countries were operating nuclear power programs at the time. Neither Taiwan nor Yugoslavia have been found in non-compliance. There are 63 NNWS NPT parties with significant nuclear activities—only five, those listed above, have been in non-compliance.[80] FOE conceded in a supplementary submission that while it was true that Taiwan and Yugoslavia were not found to be in non-compliance, they nonetheless pursued nuclear weapons programs despite being NPT signatories.[81]

7.68 In relation to the ROK, ASNO argued that it has been accepted by the IAEA Board of Governors that the activities referred to by FOE were not authorised by the ROK Government. The ROK Government was also said to have taken action to improve the effectiveness of its nuclear regulatory arrangements. FOE's assertion that the ROK has a nuclear weapons research program is unsubstantiated. When the unauthorised nuclear experiments carried out by ROK scientists were reported to the IAEA Board of Governors, the Board concluded that these activities did not amount to non-compliance with the ROK's safeguards agreement. In other words, the Board did *not* consider that the activities constituted evidence of efforts to develop nuclear weapons.[82]

7.69 In relation to the issue of civil programs providing expertise, facilities and materials to assist weapons programs ASNO responded that:

> In asserting that civil nuclear programs have facilitated covert weapons programs, is FOE suggesting that all nuclear activities should cease? Of course those countries that have pursued nuclear weapons have used scientists and engineers who have gained experience in nuclear research programs. It is hardly a serious response to this issue to proscribe all nuclear research—while

78 FOE, *Submission no. 52*, p. 18; MAPW (Victorian Branch), *Submission no. 30*, p. 4.

79 *ibid*., pp. 24, 25–26. See also: FOE, *Submission no. 52.2*, p. 4–5.

80 The Hon Alexander Downer MP, *Submission no. 33,* p. 13; The Hon Alexander Downer MP, *Submission no. 33.1*, p. 12.

81 FOE, *Submission no. 52.2*, p. 12.

82 The Hon Alexander Downer MP, *Submission no. 33.1*, p. 2.

> we're about it, why not proscribe all physics, all chemistry, all engineering, all mathematics and computing?[83]

NPT states could acquire sensitive technologies, withdraw from the Treaty and develop weapons

7.70 Whereas the previous issue related to the possibility of NPT parties conducting covert weapons programs, an alternative possibility is that, having made full use of their right to access nuclear technologies for ostensibly peaceful purposes under Article IV of the Treaty, NPT parties could acquire all the materials and expertise needed for weapons programs, then withdraw from the Treaty and proceed with weaponisation. This problem is said to have been highlighted by the DPRK and, potentially, Iran.[84]

7.71 ASNO responded that only one country, the DPRK, has attempted to withdraw from the NPT but that the DPRK's nuclear capabilities were not obtained under the NPT. Withdrawal from the NPT is also not an unqualified right. Many countries, including Australia, consider that the DPRK has not complied with the withdrawal provisions. Australia is currently active in the development of international action against any further withdrawals, for example, to establish that nuclear technology acquired during NPT membership continues to be bound by peaceful use obligations.[85]

7.72 A key issue is that Article IV of the NPT (also known as the 'right-to-peaceful-uses guarantee') enshrines the:

> … inalienable right of all Parties to the Treaty to develop research, production and use of nuclear energy for peaceful purposes without discrimination… All the Parties to the Treaty undertake to facilitate, and have the right to participate in, the fullest possible exchange of equipment, materials and scientific and technological information for the peaceful uses of nuclear energy.[86]

7.73 Mr Lance Joseph, Australian Governor on the Board of the IAEA from 1997 until 2000, explained that although the exercise of this right must be in conformity with the overriding obligation not to pursue a nuclear weapons program and the non-proliferation aims codified in Articles I and II of the Treaty, many NNWS regard their right to enjoy full access to the technologies for peaceful use as inviolate:

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83 *ibid.*, p. 12.

84 MAPW (Victorian Branch), *loc. cit.*

85 The Hon Alexander Downer MP, *Submission no. 33.1*, p. 12.

86 IAEA, *Treaty on the Non-Proliferation of Nuclear Weapons, loc. cit.*

> So the question remains how to ensure that a rogue state does not circumvent its NPT obligations using the cover of the Treaty to creep to the weapons threshold, then withdrawing from the Treaty and embarking on a full-scale weapons program. That's the dilemma currently confronting the international community in Iran, and the insistence of Iran on its right to acquire the technologies of all stages of the nuclear fuel cycle.[87]

7.74 In relation to the Iranian situation, Professor Richard Broinowski argued that:

> … Iran right now are acting perfectly legally under the NPT and the extended protocol in developing an enrichment plant. Indeed, they are encouraged to do that by the terms of the NPT and its extensions. Yet that could lead immediately to weapons-grade plutonium or uranium being developed in Iran. All you have got to do is go beyond a 20 per cent U-235 to up to 90 per cent and it is the same process.[88]

7.75 For Mr Joseph, the challenge now presented by Iran and North Korea points to a basic flaw in the NPT as it was negotiated in the 1960s, 'namely that any party should have the right to access the *full* nuclear technologies in return for its promise not to turn those skills to military use.'[89] While in the late 1960s it was thought that few countries either could or would seek to acquire the sophisticated technologies, uranium enrichment and extracting plutonium are now more widely understood and can be abused. Proposals now being considered to address this dilemma are summarised later in the chapter.

7.76 Mr John Carlson, Director General of ASNO, noted that Iran has indeed insisted that it has a right to pursue proliferation-sensitive technologies as part of the inalienable right to nuclear energy provided in Article IV of the NPT, but that:

> This is a serious misreading of the NPT. The NPT (Article IV) speaks of the right of all parties to use *nuclear energy* for peaceful purposes. This was never intended to mean development of *any* nuclear technology.[90]

7.77 Moreover, Mr Carlson argued that when the NPT was first negotiated it was envisaged that the NWS would provide enrichment and reprocessing

87 Mr Lance Joseph, *Submission no. 71*, p. 2.

88 Professor Richard Broinowski, *Transcript of Evidence*, 16 September 2005, pp. 20-21.

89 Mr Lance Joseph, *loc. cit.* Emphasis added.

90 Mr John Carson, *Safeguards and Non-Proliferation: Current Challenges and Implications for Australia*, Speech given to the 2005 Conference of the Australian Nuclear Association, Sydney, 10 November 2005, p. 4. Emphasis is original.

services for the NNWS. Furthermore, in terms of the NPT itself, the right to use of nuclear energy is not unqualified:

> … but is subject to the other provisions of the Treaty—including the commitment against seeking nuclear weapons and the commitment to place all nuclear material under IAEA safeguards. It is disturbing that the state most vociferous about this 'right'—Iran—has been selective in its observance of NPT provisions. It is even more disturbing that Iran has supporters despite its track record of NPT violations.
>
> Ultimately, the NPT is a treaty on *non-proliferation*, not technology acquisition.[91]

7.78 ASNO argued that the challenge presented by Iran points to the need for an international framework to deal with legitimate concerns about access to the benefits of nuclear science and technology, which is discussed further below.

Nuclear Weapon States are in breach of their disarmament obligations under the NPT

7.79 It was argued that some or all of the NWS are in breach of their NPT obligation to pursue good-faith negotiations on nuclear disarmament, which is enshrined in Article VI of the NPT.[92] The 'intransigence' of the NWS was said to provide incentives and excuses for other states to pursue nuclear weapons.[93] FOE argued that the allegedly problematic role of the NWS has frequently been mentioned by the Director General of the IAEA.[94] For example, in May 2005, the Director General stated that:

> … we must show the world that our commitment to nuclear disarmament is firm. As long as some countries place strategic reliance on nuclear weapons as a deterrent, other countries will emulate them. We cannot delude ourselves into thinking otherwise.[95]

7.80 Moreover, it was alleged that vertical proliferation among the NWS (e.g. Chinese ballistic missile testing and new weapons R&D in the US and

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91 ASNO, *Australian Safeguards and Non-Proliferation Office Annual Report 2004–2005*, *op. cit.*, p. 10. Emphasis in original.

92 FOE, *Submission no. 52*, p. 18; FOE, *Submission no. 52.2*, p. 9; Professor Richard Broinowski, *loc. cit*.

93 FOE, *Submission no. 52*, p. 18.

94 FOE, *Submission no. 52.2*, p. 10.

95 Dr Mohamed ElBaradei (IAEA Director General), *Treaty on the Non-Proliferation of Nuclear Weapons*, Address at the 2005 Review Conference of the Treaty on the Non-Proliferation of Nuclear Weapons, 2 May 2005, United Nations, New York, viewed 12 February 2006, <http://www.iaea.org/NewsCenter/Statements/2005/ebsp2005n006.html>.

France) violates the spirit of Article VI of the Treaty. Inaction on disarmament and activities to develop new or enhanced nuclear weapons by the NWS was said to be placing further pressure on the NPT and the non-proliferation regime generally.[96]

7.81 Professor Richard Broinowski argued that there are double standards for the parties to the Treaty:

> Under article VI, the weapons states are supposed to reduce, and then do away with, their arsenals as a bargain for the non-nuclear weapons states saying, 'We will not possess, develop or acquire nuclear weapons.' In my view, we are going to see one or two extra nuclear states every year because they are absolutely sick and tired of having to follow their part of the bargain while the superpower and the other nuclear weapons states have no intention of reducing their armaments. Indeed, the United States has new programs to make new weapons.[97]

7.82 ASNO responded that it is not plausible that a NNWS would seek nuclear weapons because the NWS are not meeting their NPT commitments. In any case, ASNO disputed that all the NWS are in breach of their NPT disarmament obligations and that a closer examination of the actual obligations is required because the NPT disarmament provisions are more complex than many critics appreciate. Article VI of the NPT requires all NPT Parties to:

> … pursue negotiations in good faith on effective measures relating to cessation of the nuclear arms race at an early date and to nuclear disarmament, and on a treaty on general and complete disarmament under strict and effective international control.[98]

7.83 ASNO stated that the disarmament commitment involves all parties, not just the NWS, and that it is neither reasonable nor consistent with the terms of the NPT to place all the onus on the NWS.

7.84 The principal weapon states, the US and Russia, have in fact concluded a series of agreements for nuclear weapons reductions. These countries have reduced deployed warhead numbers from 10 000 each in 1991 to 6 000 each in 2002, and are proceeding to levels of between 1 700 and 2 200 by 2012 in accordance with commitments contained in the 2002 Moscow Treaty on Strategic Offensive Reductions. ASNO observed that while there

96 MAPW (Victorian Branch), *op. cit.*, p. 3; AMP CISFT, *op. cit.*, p. 6; Darwin NO-WAR Committee, *Submission no. 13*, p. 3.

97 Professor Richard Broinowski, *Transcript of Evidence*, 16 September 2005, p. 21.

98 Cited in the Hon Alexander Downer, *Submission no. 33.1*, p. 6.

is clearly more to be done in warhead reductions, it is not helpful to ignore this very real progress.[99]

7.85 France and the UK have both unilaterally reduced warhead numbers. Both countries have also de-targeted their warheads. The UK has placed surplus military fissile material under IAEA safeguards, and has also placed all enrichment and reprocessing activities under safeguards. France is dismantling its military production facilities. In relation to China, ASNO argued that there is no basis for the assertion that China has no intention of fulfilling its NPT disarmament obligations.

7.86 ASNO argued that what is lacking currently are wider international efforts, involving all NPT parties, to negotiate a treaty on general disarmament, as contemplated by the NPT. Also essential to establishing the conditions for deeper cuts in nuclear arsenals is a firm commitment by all parties, NNWS as well as the NWS, to non-proliferation. The efforts of some NNWS to pursue nuclear weapons are not conducive to nuclear disarmament. The NPT implicitly recognises the fact that a stable environment in terms of non-proliferation of other forms of WMD is also an essential condition for further nuclear disarmament.[100]

The IAEA's dual role of promoting the peaceful uses of nuclear energy while preventing weapons proliferation is contradictory

7.87 The IAEA's dual role of promoting the peaceful uses of nuclear energy while also preventing weapons proliferation was argued to be 'contradictory'.[101] The MAPW (Victorian Branch) asserted that:

> … the simultaneous roles of the IAEA in discouraging actual proliferation, while assisting and promoting the spread of know-how, materials and technology relevant to weapons development is inherently contradictory, and ultimately, counterproductive.[102]

7.88 Similarly, the Darwin NO-WAR Committee argued that:

> In reality, these international mechanisms have been used to facilitate, rather than limit, the spread of nuclear technologies, facilities and materials across political boundaries.[103]

7.89 The ACF and FOE also argued that the IAEA is 'hopelessly compromised' by its mandate to promote the 'spread of dual use technology'.[104]

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99 *ibid*. See also: US Department of State, Bureau of Arms Control, *Treaty Between the United States of America and the Russian Federation On Strategic Offensive Reductions*, viewed 28 July 2006, <http://www.state.gov/t/ac/trt/18016.htm>.

100 The Hon Alexander Downer MP, *Submission no. 33.1*, p. 7.

101 FOE, *Submission no. 52*, p. 18.

102 MAPW (Victorian Branch), *op. cit.*, p. 6.

103 Darwin NO-WAR Committee, *Submission no. 13*, p. 3.

7.90 ASNO responded that there is no basis to the claim of a conflict of interest between the IAEA's safeguards responsibilities and its responsibilities to 'enlarge the contribution of atomic energy to peace, health and prosperity throughout the world'.[105] These responsibilities were argued to be complementary, not inconsistent. In practice, the IAEA's role with nuclear technology was said to be more one of facilitation and monitoring than promotion. The IAEA also has a very important role in technical assistance, making nuclear applications available to developing countries in areas such as health and agriculture. ASNO argued that:

> To claim that the IAEA's responsibilities are inconsistent is in effect to argue there should be no international cooperation on nuclear science and technology.[106]

Composition of the IAEA Board of Governors is inappropriate

7.91 FOE argued that the membership of the Board of Governors of the IAEA is weighted in favour of countries with significant nuclear programs, claiming that 13 of the 35 seats on the Board are reserved for member states which are advanced in nuclear technology in their region of the world.[107]

7.92 ASNO responded that the 35 members of the Board of Governors are appointed on the basis of the IAEA Statute. The Statute has a formula for membership of the Board which includes 'the ten members most advanced in the technology of atomic energy ... and the member most advanced in the technology of atomic energy' in eight designated regions 'in which none of the aforesaid ten is located.'[108] The remaining members (around 22) are elected with due regard to equitable representation. ASNO stated that:

> It's not clear why the submitter objects to representation on the Board of those countries with significant nuclear programs, but in any event it can be seen from this formula that the Board is widely representative.[109]

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104 FOE, *Submission no. 52.1*, p. 3; ACF, *op. cit.*, p. 9.

105 The Hon Alexander Downer MP, *Submission no. 33.1*, p. 5.

106 *ibid.*, p. 6.

107 FOE, *Submission no. 52*, p. 18.

108 Cited in the Hon Alexander Downer MP, *Submission no. 33.1*, p. 13.

109 *ibid.*

7.93 In a supplementary submission FOE responded that 'countries with significant nuclear programs may have reason, e.g. commercial reasons, to downplay the proliferation risks associated with civil nuclear programs.'[110]

Timeliness in detecting diversions of fissile material

7.94 FOE claimed that another problem is the timeliness of detecting diversions of fissile material. It was argued that plutonium and HEU could be diverted and incorporated into a nuclear weapon in a short space of time.[111]

7.95 ASNO responded that the IAEA has set its timeliness and quantity goals for verification of nuclear materials on the basis of conversion times (i.e. how long it would take to turn the material into a nuclear explosive device) based on the conservative assumption that all preparatory work has already been done. This preparatory work includes the construction and commissioning of relevant facilities, such as an enrichment or reprocessing plant. In practice, far greater warning times should be available than simply the IAEA's timeliness goals. Part of the IAEA's program to strengthen safeguards includes developing detection capabilities to find undeclared facilities, and information analysis to identify indicators of preparations to proliferate.[112]

Possible diversion of nuclear 'Material Unaccounted For'

7.96 Another 'unresolved' proliferation issue was said to be 'Material Unaccounted For' (MUF)—discrepancies between the expected and measured amounts of nuclear material. This was said to be a particularly difficult problem for large throughput facilities (such as reprocessing, enrichment and fuel fabrication plants), where it is alleged that enough fissile material could be diverted to make several weapons without detection.[113] The Arid Lands Environment Centre (ALEC) claimed that:

> In the most up-to-date reprocessing plants ever built (currently being commissioned in Japan at Rokkasho-Mura), an accountancy level of 99% is being promised. That is, the operators guarantee to within 1% that all of the material (such as weapons-grade plutonium) received by the plant is accounted for. At that rate of assurance, this one facility alone will provide enough 'missing'

110 FOE, *Submission no. 52.2*, pp. 12–13.

111 FOE, *Submission no. 52*, p. 19.

112 The Hon Alexander Downer MP, *Submission no. 33.1*, p. 13.

113 FOE, *Submission no. 52*, *loc. cit.*; FOE, *Submission no. 52.2*, p. 3; MAPW (Victorian Branch), *Exhibit no. 79, Safeguards and Plutonium Reprocessing*, p. 5.

> material to power a nuclear weapon every month. And this is the best that the industry can offer ...[114]

7.97 AMP CISFT also expressed concern about clerical errors at the Sellafield reprocessing facility in the UK which allegedly meant that up to 30 kg of plutonium could not be accounted for each year.[115]

7.98 ASNO responded that MUF is a normal occurrence in the verification of nuclear accounts. MUF is the difference between recorded quantities and measured quantities of nuclear materials. MUF does not imply that nuclear material is missing—as often as not, the measured quantity will be greater than the recorded quantity, i.e. material will be 'gained'.[116]

Resource constraints on the IAEA's safeguards activities

7.99 FOE and others argued that: 'Resource constraints on the IAEA's safeguards system are an ongoing problem'.[117] The Director General of the IAEA has himself remarked that 'the Agency's verification activities operate on a shoestring budget, particularly given the expanding scope of [IAEA] responsibilities.'[118] As noted above, the Agency's annual safeguards budget is approximately US$130 million. The IAEA employs some 650 inspectors who oversee approximately 900 nuclear facilities in 71 countries. In order to address resource constraints, the Agency is exploring use of innovative technologies for detecting undeclared facilities and activities.[119] Nonetheless, the Director General has observed that 'we are clearly operating on a "bare minimum" of funding'.[120]

7.100 In relation to financial and personnel resource constraints on the IAEA's capacity to implement its strengthened safeguards program, ASNO stated that for the period from the early 1990s to 2003 the IAEA operated under the constraints of a 'zero real growth' budget applied by the member states, in line with similar action in other UN bodies. In recognition of the increased workload facing the IAEA, in 2003 the IAEA Board of

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114 ALEC, *Submission no. 75*, p. 3.

115 Dr Ian Woods (AMP CISFT), *Transcript of Evidence*, 16 September 2005, p. 29.

116 The Hon Alexander Downer MP, *Submission no. 33.1*, p. 2.

117 FOE et. al., Exhibit no. 71, *Nuclear Power – no solution to climate change*, section 3.6.

118 Dr Mohamed ElBaradei, *Nuclear Non-Proliferation and Arms Control: Are We Making Progress?*, Statements of the Director General, Speech to the 2005 Carnegie International Non-Proliferation Conference, 7 November 2005, viewed 7 August 2006, <http://www.iaea.org/NewsCenter/Statements/2005/ebsp2005n017.html>.

119 *ibid*.

120 Dr Mohamed ElBaradei, *Nuclear Non-Proliferation: Responding to a Changing Landscape*, Statement by the IAEA Director General, 18 May 2006, viewed 8 August 2006, <http://www.iaea.org/NewsCenter/Statements/2006/ebsp2006n007.html>.

Governors agreed to a substantial increase—around 16 per cent—in the regular safeguards budget.[121]

7.101 Savings in safeguards costs are expected from the introduction of 'integrated safeguards', which allow for the rationalisation of safeguards activities in states where the IAEA has concluded there are no indications of undeclared nuclear material or activities. These savings will be available to offset increasing costs in other areas of safeguards implementation. Member states are also keeping the adequacy of the safeguards budget under review.

International safeguards are of no relevance to non-NPT member states

7.102 FOE claimed that an on-going limitation of the NPT/IAEA safeguards system is that it is of no relevance to non-NPT states—India, Pakistan, Israel and, since its withdrawal, North Korea.[122]

7.103 In contrast, ASNO stated that the NPT is not irrelevant to the three non-NPT parties, arguing that their national security benefits substantially from the stable non-proliferation environment which the NPT provides. It was also observed that, to a significant extent, theses countries are bound by the non-proliferation commitments of the NPT, in the sense that they should not assist a party to break its commitment not to pursue nuclear weapons. Moreover, as noted in the overview of the IAEA safeguards agreements above, all three non-NPT parties accept IAEA safeguards on some of their facilities.[123]

Vulnerabilities and challenges to the non-proliferation regime

7.104 ASNO argued that the greatest challenge for the non-proliferation regime is the weakening of political support for the NPT itself, evidenced by the failure of the 2005 NPT Review Conference to agree on any final document, notwithstanding that proliferation is widely seen as a serious threat.[124]

7.105 ASNO commented in its *2004–2005 Annual Report* that this loss of support is not occurring deliberately but more out of neglect, or lack of appreciation for the national security benefits of an effective non-proliferation regime. ASNO observed that many developing countries regard proliferation as a 'North/South' issue which is important only to

121 The Hon Alexander Downer MP, *Submission no. 33.1*, p. 14. See also: US Government Accountability Office (GAO), *Nuclear Nonproliferation*, GAO, Washington DC, October 2005, viewed 25 November 2005, <http://www.gao.gov/new.items/d0693.pdf>.

122 FOE, *Submission no. 52*, p. 19.

123 The Hon Alexander Downer MP, *Submission no. 33.1*, p. 13.

124 ASNO, *Annual Report 2004–2005, op. cit.*, p. 6.

the 'North' and can therefore be used as a bargaining chip in other political arguments. Moreover, for many countries the focus of interest in the NPT now seems to be 'almost exclusively disarmament and technology acquisition. The non-proliferation core of the Treaty has receded in importance.'[125] However, ASNO argued that disarmament will not progress further while proliferation is becoming an increasing problem and, therefore, those countries who genuinely wish to encourage disarmament should support the non-proliferation aspects of the Treaty.

7.106 ASNO noted that one important positive development of the 2005 Review Conference was that NPT parties for the first time debated the issue of NPT withdrawal. Parties showed support for stronger disincentives to withdrawal and many NPT parties made clear that they regard NPT withdrawal as an issue of the highest concern.[126]

7.107 Despite the inability of the Review Conference to reach consensus on measures to address the compliance and verification challenges facing the NPT, ASNO argued that Australia, along with the overwhelming majority of states, continue to support the NPT and value highly the security benefits it delivers. It was argued that the Treaty 'remains of strong normative value as a near-universal instrument setting the benchmark for nuclear non-proliferation and disarmament.'[127]

7.108 ASNO also noted that it is important to recognise that the NPT's future does not hinge on the outcome of the 2005 Review Conference. The failure to produce a final document, while disappointing, was not a fatal blow. Several previous Review Conferences have also failed to produce final documents.

7.109 Since the Conference, non-proliferation objectives have been pursued in other forums, including the following:

- in June 2005 the IAEA Board of Governors decided to establish a special committee on safeguards and verification to examine ways to strengthen safeguards;
- the IAEA's Standing Advisory Group on Safeguards Implementation now meets regularly to consider improved nuclear safeguards approaches;
- a conference in July 2005 agreed on amendments to the *Convention on the Physical Protection of Nuclear Material* (CPPNM) to extend its application;

125 *ibid*.

126 The Hon Alexander Downer MP, *Submission no. 33.4*, p. 1.

127 *ibid*., p. 2.

- the NSG has met and discussed the current proliferation challenges of North Korea and Iran, and the strengthening of nuclear export controls; and
- parties to the Comprehensive Test Ban Treaty (CTBT) met in September 2005 to identify ways to accelerate entry into force of the CTBT.[128]

7.110 ASNO noted that while multilateral treaty regimes and supporting measures such as export controls are important defences against nuclear proliferation, they are not of themselves enough to stop determined proliferators. To this end, the PSI is said to have 'quickly proved its worth as a means of strengthening governments' ability to disrupt illicit trade in WMD materials and their delivery systems.'[129]

7.111 The AMP CISFT argued that long-lived nuclear waste also poses a challenge for the non-proliferation regime because of the time frames in which the waste must be isolated and managed. It was argued that the life span of the waste from nuclear reactors means that non-proliferation measures need to consider not just the current geopolitical situation but also the situation over the next 200 or more years:

> You might set up a framework which works within the current view of the world, but you actually need something which can transcend that, given the changes that can occur in the political arena.[130]

7.112 Similarly, the MAPW (Victorian Branch) insisted that the long time frames required for some radioactive material to decay was a sufficient reason for Australia to cease uranium exports:

> Even if Australia makes decisions today about the likely compliance or the documented compliance of countries with their safeguards obligations, either multilateral or bilateral, even if Australia makes assessments now about the weapons interests or aspirations of countries to which it may export nuclear materials, those assessments may be valid this year or even next year, but they are not valid in 10 years time, in 50 years time, in 100 years time, in 1,000 years time, in a couple of hundred thousand years time. You are talking about materials whose physical inherent nature involves time frames of hundreds of thousands of years of toxicity.[131]

128 *ibid.*, pp.1–2.
129 *ibid.*, p. 2.
130 Dr Ian Woods, *op. cit.*, p. 30.
131 Associate Professor Tilman Ruff, *op. cit.*, p. 25.

7.113 In terms of other challenges to the non-proliferation regime, the Director General of the IAEA has spoken of three post-cold war developments that have altered the nuclear security landscape: the emergence of clandestine nuclear supply networks; the spread of fuel cycle technologies; and renewed efforts by a few countries and some terrorist groups to acquire nuclear weapons. These developments are said to have highlighted several vulnerabilities in the non-proliferation regime, including the limitations on the IAEA's verification authority, control of proliferation-sensitive technologies, and the IAEA's technical capability to detect undeclared nuclear activities.[132]

Proposals to strengthen the non-proliferation regime

7.114 Evidence was presented which contained proposals to address two of the key challenges noted in the preceding section—controlling the further spread of proliferation sensitive technologies and enhancing the effectiveness of the nuclear verification regime.

Controlling proliferation-sensitive technology

7.115 As noted at the beginning of the chapter, the importance of ensuring effective control over the proliferation-sensitive technologies of uranium enrichment and reprocessing, including limiting their spread, has long been recognised. In light of recent developments, notably the withdrawal of North Korea from the NPT and the Iranian situation, the need to limit the spread of sensitive technology is assuming increased urgency.

7.116 The NPT itself does not directly address this issue, other than through the commitments undertaken by NNWS not to seek nuclear weapons, not to divert nuclear energy from peaceful uses to nuclear weapons, and to accept IAEA safeguards to verify fulfilment of these commitments. ASNO explained that when the NPT was concluded it was expected that development of enrichment and reprocessing would be too complex and too expensive to be practicable for most countries. Instead, it was anticipated that the existing technology holders, principally the NWS, would provide fuel cycle services to other states. This is essentially what has occurred, with the world's reactors fuelled by enrichment services provided by the US, UK, France and Russia, together with Germany and

132 Dr Mohamed ElBaradei, *Nuclear Non-Proliferation and Arms Control: Are We Making progress?, loc. cit.*

the Netherlands. Reprocessing services are provided by the UK and France.[133]

7.117 The main international barrier to the spread of enrichment and reprocessing technologies has been the guidelines on sensitive technology transfers established through the NSG. However, the development of indigenous technology by some countries, and especially the emergence of a black market based on stolen enrichment technology, demonstrate the need for additional measures.

7.118 The issue has been highlighted by the situation of Iran, which claims it needs to develop enrichment to ensure security of supply of nuclear fuel. ASNO commented that Iran's argument about its 'right' to develop the full fuel cycle should be seen against the following facts:

- Iran does not actually have a nuclear power program—it has only one power reactor under construction;
- Russia, which is building the reactor in question, has undertaken to supply fuel for 30 years; and
- Iran has developed its enrichment program, and undertaken other nuclear activities, in secret over a period of some 20 years. This contravenes its IAEA safeguards agreement and the NPT, both of which require all nuclear activities and nuclear material to be placed under IAEA safeguards. As noted above, the IAEA Board of Governors has determined that Iran is in non-compliance with its safeguards agreement.[134]

7.119 ASNO submitted that what is needed is a framework for international cooperation, under which states can be assured of access to nuclear fuel and reactors on reasonable and non-discriminatory terms in exchange for eschewing national development of proliferation-sensitive technologies. It was proposed that such a framework could include a combination of measures along the following lines:

- criteria for assessing the international acceptability of proposed sensitive projects—e.g. the non-proliferation/safeguards credentials of the country concerned; whether there is a clear economic/energy rationale for the project; whether the country is located in a region of tension, and so on;
- a more rigorous safeguards regime for countries with sensitive facilities;

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133 The Hon Alexander Downer MP, *Submission no. 33.2*, p. 2.

134 *ibid.*, p. 3.

- internationally guaranteed supply assurances to ensure reliable access to reactor fuel for countries that forgo national enrichment and reprocessing capabilities; and
- possibly, establishment and operation of sensitive facilities on a multination basis.[135]

7.120 In 2004 the IAEA commissioned a study by a group of international experts on possible multilateral approaches to address concerns over the dissemination of proliferation-sensitive technologies. The study covered the interwoven issues of 'assurances of supply' and 'restraints for use' together with the concept of 'multinational fuel cycle facilities'. The study drew extensively from a similar international review coordinated by the IAEA in the 1970s and early 1980s—the International Nuclear Fuel Cycle Evaluation (INFCE).

7.121 The report by the expert group, *Multilateral Approaches to the Nuclear Fuel Cycle*, outlined five multilateral nuclear approaches (MNAs) which could be gradually introduced to strengthen controls over enrichment, reprocessing, spent fuel repositories and spent fuel storage. It was concluded that these approaches would achieve the objective of increasing non-proliferation assurances associated with the civilian nuclear fuel cycle, while preserving assurances of supply and services:

- reinforce existing commercial market mechanisms on a case-by-case basis through long-term contracts and transparent suppliers' arrangements with government backing. Examples would be: fuel leasing and fuel take-back, commercial offers to store and dispose of spent fuel and commercial fuel banks;
- develop and implement international supply guarantees with IAEA participation, notably with the IAEA as guarantor of service supplies, e.g. as administrator of a fuel bank;
- promote voluntary conversion of existing facilities to multilateral control, and pursue them as confidence-building measures, with the participation of NPT NNWS and NWS, and non-NPT states;
- create, through voluntary agreements and contracts, multinational, and in particular regional, MNAs for new facilities based on joint ownership, drawing rights or co-management for front-end and back-end nuclear facilities, such as uranium enrichment, fuel reprocessing, disposal and storage of spent fuel; and
- the scenario of a further expansion of nuclear energy around the world might call for the development of a nuclear fuel cycle with stronger

135 *ibid*.

multilateral arrangements—by region or by continent—and for broader cooperation, involving the IAEA and the international community.[136]

7.122 Mr Lance Joseph, who was a member of the independent expert group that prepared the report, felt that the group was most positive about the more modest proposal—that the IAEA could take on additional multilateral functions, including by becoming a multilateral guarantor of supply of nuclear material and services.[137]

7.123 It was noted however that negotiating such an arrangement would not be easy and nor would the existence of such multilateral alternatives necessarily stop committed proliferators, or countries wishing to acquire their own capacity:

> Still, for a large body of states, a satisfactory multilateral option for guaranteeing reliable and adequate supplies of fuel and services might well prove preferable to an independent, but more problematic alternative.[138]

7.124 It was argued that Australia should perform a 'catalytic role' on behalf of the IAEA-as-guarantor idea because, firstly, Australia is said to have the requisite non-proliferation credentials as well as respect and credibility within the IAEA, but also for reasons of national self-interest:

> … Australia, anxious to boost uranium sales but still constrained by political concerns not to fuel the proliferation threat, must surely have a vested interest in any initiative designed to limit the spread of dangerous technologies. Viewed in the proper light, an active role in encouraging further examination of the proposal might be seen as an opportunity rather than as a burden, with the prospect for an outcome that could measurably advance the non-proliferation cause.[139]

7.125 ASNO responded that although Australia is a major supplier of uranium, the nation is not well placed to take on a catalytic role because the issue of supply guarantees relates much more to enrichment services, and also to fuel fabrication services, than to uranium supply. That is, while uranium is, or could be, supplied by many countries, enrichment is supplied by a relative handful.[140]

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136 IAEA, *Multilateral Approaches to the Nuclear Fuel Cycle* (INFCIRC/640), IAEA, Vienna, 2005, p. 15, viewed 16 January 2006, <http://www.iaea.org/Publications/Documents/Infcircs/2005/infcirc640.pdf>. Emphasis in original.

137 Mr Lance Joseph, *op. cit.*, p. 3.

138 *ibid.*

139 *ibid.*

140 The Hon Alexander Downer MP, *Submission no. 33.2*, p. 5.

7.126 Since the expert group on multilateral approaches reported in February 2005, the Director General of the IAEA has proposed that the move towards multinational arrangements for enrichment and plutonium separation should progress as a series of four measures:

- provide assurance of supply of reactor technology and nuclear fuel for all bona fide users for peaceful civilian applications;
- accept a time-limited moratorium (of perhaps 5–10 years) on new uranium enrichment and plutonium separation facilities—at the very least for countries that do not currently have such technologies;
- establish a framework for multilateral management and control of the back end of the fuel cycle (i.e. spent fuel reprocessing and waste disposal); and
- create a similar framework for multilateral management and control of the front end of the fuel cycle (i.e. enrichment and fuel production).[141]

7.127 The G8, the NSG as well as various governments are now considering multi-nation arrangements to limit the spread of proliferation-sensitive technologies. The Director General of the IAEA has noted that progress is already being made on the first measure—nuclear fuel supply guarantees for those countries willing to foreswear developing enrichment and reprocessing technologies. It is hoped that assurance of supply will remove the incentive and the justification for each country to develop its own complete fuel cycle. Two ideas are currently under development:

- the IAEA is developing a concept where the Agency would have available reserves of nuclear material in cooperating countries which it could release for supply to qualifying countries; and
- the US has announced a proposal to reserve an initial 17.4 metric tons of its surplus weapons-program HEU for downblending and use as civil reactor fuel, to be available to countries that forswear the development of enrichment and reprocessing.[142]

7.128 Russia has also indicated that it will make fuel available to the IAEA to be used as part of an Agency fuel bank.[143] In September 2006 the IAEA will host a conference to further examine frameworks for assurances of supply.[144]

141 Dr Mohamed ElBaradei, *Nuclear Non-Proliferation and Arms Control: Are We Making Progress?*, *loc. cit*.

142 The Hon Alexander Downer MP, *Submission no. 33.2*, p. 5.

143 See for example: Dr Mohamed ElBaradei, *Putting Teeth in the Nuclear Non-Proliferation and Disarmament Regime*, Statement by the IAEA Director General, 25 March 2006, viewed 8 August 2006, <http://www.iaea.org/NewsCenter/Statements/2006/ebsp2006n004.html>.

144 See: IAEA, *Special Event in September: Assurances of Nuclear Supply and Non-Proliferation*, viewed 8 August 2006, <http://www.iaea.org/NewsCenter/News/2006/assurancesofsupply.html>.

7.129 Mr Jerry Grandey, Chief Executive Officer of Cameco, suggested that as part of the current discussion of multilateral proposals, Australia (along with Canada) could play a role in assurance of supply of fuel for those countries that agree to forego development of weapons.[145]

7.130 ASNO noted that while multilateral approaches are unlikely to dissuade a country intent on developing fuel cycle technology for military purposes, the proposals will at least:

> … expose the real reasons for a country's actions. If a country insists on proceeding with indigenous enrichment or reprocessing because of concerns about 'energy security', despite being given long term fuel supply guarantees, the international community can draw its own conclusions and act accordingly.[146]

7.131 Nonetheless, as noted above, a key political issue is that some states, particularly Iran and some members of the Non-Aligned Movement (NAM), emphasise the 'right' to develop the full nuclear fuel cycle while ignoring the corresponding duty to comply with NPT and safeguards commitments. Furthermore, a number of NAM members are said to be concerned that limits on the spread of sensitive technology will entrench the 'monopoly' position of existing technology holders. ASNO argued that this overlooks the fact that, far from being monopolistic, the current market for fuel cycle services is highly competitive and buyers benefit from low prices. In any event, customers can seek to acquire a shareholding in a fuel service provider. Moreover, ASNO argued that, under current circumstances, with established global enrichment and reprocessing capacities exceeding demand, the development of indigenous enrichment/reprocessing is not economic, except possibly in the case of countries with very large power programs (e.g. Japan with 55 power reactors). The majority of the world's nuclear power programs are based on external fuel cycle service providers.[147]

7.132 ASNO observed that developing the framework described above is a difficult objective to pursue because of widely competing national interests. In particular, the proposal of multi-nation operation of sensitive facilities has been considered in the past without particular progress and that: 'Further advances seem unlikely in the short term.'[148]

7.133 FOE were sceptical of the potential of multi-nation control of proliferation-sensitive technologies because it claimed that while these initiatives may reduce the risk of horizontal proliferation, the potential for diversion of

145 Mr Jerry Grandey (Cameco Corporation), *Transcript of Evidence*, 11 August 2005, p. 12.

146 The Hon Alexander Downer MP, *Submission no. 33.2*, p. 4.

147 *ibid*.

148 The Hon Alexander Downer MP, *Submission no. 33*, p. 3.

materials by customer countries could not be eliminated. FOE also noted that such proposals are likely to face 'insurmountable opposition' in practice.[149]

7.134 Professor Broinowski recommended that Australia work with like minded countries to develop a new non-proliferation Treaty, including abolishing the right of countries to access sensitive technologies under the NPT. Professor Broinowski also supported proposals for the IAEA to lease fuel for countries with nuclear power, thereby obviating the need for yet more countries to develop domestic enrichment technology.[150]

7.135 However, Mr Joseph observed that amending the NPT has been considered and is thought to be highly problematic:

> … any careful balancing of the divergent interests in the NPT suggests that any attempt to renegotiate the Treaty or reinterpret the Treaty—especially if directed explicitly at curtailing nuclear access even for peaceful purposes—would be a fraught exercise. Therefore, a more pragmatic approach to amending or reinterpreting the Treaty is needed.

7.136 It is for this reason, Mr Joseph stated, that multilateral approaches to control over proliferation-sensitive technologies are being pursued.

Improving the effectiveness of the verification regime

7.137 ASNO explained that strengthening safeguards, particularly to detect undeclared nuclear activities, involves technical and political aspects. At the technical level is the need to improve detection methods, and at the political level there is the need to extend the IAEA's authority to require information and physical access through universalisation of the AP. Another important technical goal is the development of proliferation-resistant technologies, which are considered separately below.[151]

7.138 Central to the effort to strengthen safeguards is the effective use of information—involving collection and analysis of information that can enhance the IAEA's knowledge and understanding of nuclear programs—and providing more extensive rights of access to nuclear and nuclear-related locations, including for the resolution of questions arising from information analysis. Major areas of safeguards development include:

- detection methods for undeclared activities—including environmental sampling/analysis, satellite imagery and new sensing technologies;

149 FOE, *Submission no. 52*, p. 19.

150 Professor Richard Broinowski, *Transcript of Evidence*, 16 September 2005, pp. 23, 24.

151 The Hon Alexander Downer MP, *Submission no. 33.2*, p. 6.

- safeguards procedures—particularly greater use of unpredictability in inspections (e.g. through unannounced or short-notice inspections); and
- the state-level approach—tailoring safeguards implementation to state specific circumstances—moving from the uniform approach taken by safeguards in the past, and basing safeguards intensity on expert judgment taking account of all relevant circumstances.[152]

7.139 ASNO explained that the IAEA's verification authority is defined principally by the safeguards agreement between the IAEA and each country, and the IAEA's own Statute. The principal limitation in safeguards agreements relates to rights of access for IAEA inspectors. Under 'traditional' safeguards, access for routine inspections is limited to 'strategic points' at facilities. This limitation was exploited by Iraq, which was able to conduct undeclared activities at safeguarded sites, at locations which inspectors were not entitled to access. This limitation is largely addressed by the AP, which, as noted above, introduces the concept of 'complementary access', substantially extending the locations to which inspectors are able to go.[153]

7.140 However, the Director General of the IAEA, along with ASNO, has stated that adoption of APs has been disappointing and still falls well short of universal application. Dr ElBaradei has argued that:

> The Agency's verification efforts will not be judged fully 'effective' on a global scale as long as its access rights remain uneven. The additional protocol must become the universal standard for verifying nuclear non-proliferation commitments.[154]

7.141 To address situations where proliferation concerns have created a 'confidence deficit', such as in Iran, the Director General has proposed that additional 'transparency measures' be required of such countries, beyond those contained in safeguards agreements and the AP, to enable the IAEA to provide the required assurance about the peaceful nature of a country's nuclear program.[155]

7.142 Another form of limitation, receiving international attention at the moment, concerns the IAEA's verification rights with respect to 'weaponisation' activities. Current safeguards agreements are expressed in terms of verification of nuclear material. Certain weaponisation activities do not involve nuclear material, and are 'dual-use' in nature, i.e. are not irrefutably limited to nuclear applications. Examples include experiments

152 *ibid.*

153 *ibid.*, pp. 7–8.

154 Dr Mohamed ElBaradei, *Nuclear Non-Proliferation and Arms Control: Are We Making Progress?, loc. cit.*

155 *ibid.*

with high-explosive lenses, acquisition of particular types of high-energy electrical circuits, and certain types of high-speed cameras. Also there are certain non-nuclear materials, such as beryllium, polonium and tritium, which may evidence nuclear weapon intent but also could have other explanations.[156]

7.143 ASNO explained that the conventional view is that for the IAEA to have a right of access to investigate such activities there must be a clear nexus with nuclear material. For example, high-explosive testing with a uranium target would be a sufficient nexus, whereas high explosive testing with a target of non-nuclear material might not be.

7.144 ASNO advised that this issue requires more deliberation by governments and the IAEA itself. However, Australia is active in pursuing analysis and debate on these issues by governments and the IAEA, with the object of further strengthening the non-proliferation regime.[157]

7.145 The Director General of the IAEA has explained that another key to making verification activities effective is the availability of sufficient resources. As noted in the discussion of limitations of the non-proliferation regime, the IAEA states that its verification activities are operating with a 'bare minimum' of funding. The IAEA is also facing recruitment challenges and recognises that it must remain in the market for innovative technologies for use in its verification program.[158]

7.146 In addition to achieving greater control over proliferation-sensitive technology and enhancing the effectiveness of nuclear verification, in recent statements the Director General of the IAEA has also proposed a further three measures to address the vulnerabilities described in the preceding section and to strengthen the non-proliferation regime: accelerate global efforts to protect nuclear material; reinvigorate disarmament efforts; and increase the effectiveness of the UN Security Council.[159]

Proliferation resistant technologies

7.147 In addition to the institutional and technical proposals to strengthen the non-proliferation regime described above, a number of other technical measures are also under consideration, specifically, the development of proliferation-resistant technologies. Proliferation resistance refers to

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156 The Hon Alexander Downer MP, *Submission no. 33.2*, p. 8.

157 *ibid.*, p. 8.

158 Dr Mohamed ElBaradei, *Nuclear Non-Proliferation: Responding to a Changing Landscape*, *loc. cit.*

159 See for example: Dr Mohamed ElBaradei, *Putting Teeth in the Nuclear Non-Proliferation and Disarmament Regime*, *loc. cit.*; Dr Mohamed ElBaradei, *Nuclear Non-Proliferation: Responding to a Changing Landscape*, *loc. cit.*

characteristics of a nuclear energy system that impedes the diversion or undeclared production of nuclear material, or misuse of technology, to acquire nuclear weapons or other nuclear explosive devices.[160] These technologies include the development of a nuclear fuel cycle that does not require enrichment and currently-established reprocessing technologies, and the development of reactor types that incorporate proliferation resistance into the reactor design.[161] These technological developments are considered in the following sections.

Advanced Fuel Cycle Initiative and Generation IV reactors

7.148 ANSTO submitted that the next series of nuclear power reactors, called Generation IV, are being designed to be proliferation-resistant through improvements in the fuel cycle (Advanced Fuel Cycle Initiative), to better integrate waste management issues and to enhance physical protection. Work on such designs is underway through the Generation IV International Forum (GIF), with the input of IAEA member states through the International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO).[162]

7.149 ANSTO and ASNO explained that achieving sustainable growth of nuclear energy will require a transition from the current once-through fuel cycle to an advanced fuel cycle that recycles nuclear materials. Recycling plutonium offers significant advantages for efficient uranium utilisation (it could extend world uranium resources by a factor of about 60) and waste management. One such fuel cycle is the so-called fast neutron fuel cycle, the basis of which is the use of fast (unmoderated) neutrons to convert the predominant uranium isotope U-238 to plutonium, and the use of that plutonium as reactor fuel.[163]

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160 ANSTO, *Submission no. 29*, p. 19.

161 See for example: Dr Mohamed ElBaradei, *Nuclear Technology in a Changing World: Have We Reached a Turning Point?*, Statements of the Director General, Address at the Massachusetts Institute of Technology, 3 November 2005, IAEA, viewed 9 December 2005, <http://www.iaea.org/NewsCenter/Statements/2005/ebsp2005n016.html>.

162 ANSTO, *op. cit.*, p. 18. Three generations of reactors have existed from the 1940s to the present. Generation I consisted of early prototype reactors of the 1950s and 1960s and none are now operating outside the UK. Generation II systems, patterned after Generation I reactors, began operation in the 1970s and comprise most of the large commercial power plants currently operating in the US and elsewhere. Generation III systems are Advanced Reactors and were developed in the 1980s. These include a number of evolutionary designs that offer significant advances in safety and economics. A number of Generation III systems have been built, primarily in East Asia. Generation IV systems are still being designed and are not expected to be operational before 2020 at the earliest. See: UIC, *Advanced Nuclear Power Reactors*, Nuclear Issues Briefing Paper 16, December 2005, viewed 9 August 2006, <http://www.uic.com.au/nip16.htm>.

163 *ibid.*; ASNO, *Exhibit no. 93*, p. 6.

7.150 The Advanced Fuel Cycle Initiative (AFCI) is a US R&D program, the mission of which is:

> To develop proliferation resistant spent nuclear fuel treatment and transmutation technologies in order to enable a transition from the current once-through nuclear fuel cycle to a future sustainable, proliferation-resistant closed nuclear fuel cycle.[164]

7.151 AFCI aims to develop a fuel cycle that does not produce plutonium which could be diverted for weapons, to reduce the inventory of civilian plutonium and to reduce the heat and toxicity of waste. It is intended that these technologies will be deployed to support current nuclear power plants and, eventually, Generation IV systems. A spent fuel separation process is being pursued under ACFI that would extract a mixture of plutonium and neptunium that would be unusable for weapons purposes from Generation IV spent fuel.[165]

7.152 Among the goals of the GIF, which involves a group of 10 countries and Euratom (China and Russia have also recently been admitted), are the development of reactor designs which are proliferation resistant. The GIF have selected six reactor technologies for further development which they believe represent the future shape of nuclear energy. Dr Ian Smith, Executive Director of ANSTO, explained that these reactors, which are expected to be deployed around 2030, will require refuelling every 20 or more years, thereby greatly reducing access to nuclear material.[166]

7.153 For financial year 2005, the US Government has appropriated US$79.2 million and $54.5 million to ACFI and Generation IV respectively. The request for financial year 2007 was $243 million for ACFI and $31.4 for Generation IV.[167]

7.154 MAPW argued that the new reactor technologies will increase rather than reduce plutonium hazard and proliferation risks, because Generation III reactors use mixed oxide fuel (MOX) (fuel that mixes uranium dioxide and plutonium dioxide) and fast breeder reactors (FBRs) will essentially operate on plutonium:

> What both of those do is increase the amount, the transport, the handling and the number of facilities that handle very large quantities of plutonium. We are not talking kilogram quantities

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164 ANSTO, *Exhibit no. 74, Presentation by Dr Ron Cameron and Dr Ian Smith,* slide 57.

165 ANSTO, *Submission no. 29*, p. 20.

166 Dr Ian Smith (ANSTO), *Transcript of Evidence*, 13 October 2005, p. 13.

167 See: US Department of Energy (DOE), *Advanced Fuel Cycle Initiative*, Program Overview, January 2006, viewed 9 August 2006, <http://nuclear.gov/infosheets/afci.pdf>; DOE, *Generation IV Nuclear Energy Systems Initiative*, Program Overview, January 2006, <http://nuclear.gov/infosheets/geniv.pdf>.

> here, we are talking tonnes, and plutonium that is highly suited for use in weapons. The potential direction of reactor technology in terms of generation III and IV reactors would take us much further in a dangerous direction from a plutonium hazard and proliferation point of view.[168]

7.155 FBRs are one type of fast neutron reactor (FNR), which deliberately use the U-238 as well as the fissile U-235 isotope to generate energy. If FNRs are designed to produce more plutonium than they consume, they are called FBRs, or 'breeders', and if they are net consumers of plutonium they are called 'burners'.

7.156 To date, the plutonium separated from reprocessing spent reactor fuel has been recycled to make MOX for use in conventional light water reactors (LWRs). FBRs, such as the Phenix reactor in France and the Monju reactor in Japan, have also used MOX fuel, but with a relatively high proportion of plutonium, surrounded by a blanket of depleted uranium (thus providing a use for the millions of tonnes of tails left after the uranium enrichment process, which are currently treated as waste) to produce further plutonium. However, the plutonium produced in FBRs has a very high proportion of Pu-239 and is thus suitable for weapons. Moreover, the blanket material needs to be reprocessed to separate the plutonium, and these factors present proliferation concerns, as noted by MAPW.[169]

7.157 However, ASNO argued that attention is now being given to FNR concepts, such as the Russian BREST reactor and the US General Electric Super-PRISM reactor, in which spent fuel undergoes simplified reprocessing which avoids plutonium separation.[170] Of the six Generation IV technologies selected for further R&D by GIF, three are FNRs and a fourth may be constructed as a fast reactor.[171]

7.158 In the case of the BREST reactor, plutonium with an isotopic composition suitable for weapons is never produced. Reprocessing and fuel fabrication would also take place at the power plant site, eliminating any physical protection issues associated with long-distance shipments of fuel. The concept also offers major advantages for waste management with fission products and actinides recycled for transmutation, substantially reducing the period of radiotoxicity—the resulting high level waste would decay to

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168 Associate Professor Tilman Ruff (MAPW), *Transcript of Evidence*, 19 August 2005, p. 32.

169 ASNO, *Exhibit no. 93, op. cit.*, p. 6.

170 *ibid.*, pp. 10, 11.

171 UIC, *Fast Neutron Reactors*, Briefing Paper No. 98, June 2006, viewed 9 August 2006, <http://www.uic.com.au/nip98.htm>.

levels comparable with natural uranium within 200 years.[172] In the case of the Super-PRISM reactor concept, on-site processing of the spent fuel is also a design option.

7.159 Thus, ASNO argued that while the increasing use of plutonium fuels and the development of a plutonium breeding cycle could present a substantial challenge to non-proliferation objectives, if concepts such as those mentioned above are established then uranium enrichment and current reprocessing technology will be phased out. If developed in an appropriate way, 'plutonium recycle could actually bring major non-proliferation advantages.'[173]

7.160 The Committee also received some evidence concerning other reactor designs, some of which are now being tested in Japan and China, which offer non-proliferation advantages. These so-called Advanced Reactor types include the modular high temperature gas-cooled reactors (MHTGCRs), of which the South African Pebble Bed Modular Reactor (PBMR) and the General Atomics (GA) Gas Turbine-Modular Helium Reactor (GT-MHR) are at an advanced stage of development. Professor Leslie Kemeny noted that the spent fuel from these reactors is highly proliferation-resistant.[174]

7.161 GA noted that the MHR can use diverse fuels, including LEU, spent fuel from conventional LWRs, weapons-grade plutonium (so the reactor can consume plutonium from weapons programs), and also utilise thorium-based fuels. Furthermore, the properties of the MHR and its fuel (which is in the form of particles less than a millimetre in diameter known as 'TRISO' fuel) allows for a so-called 'deep burn', which enables a more efficient approach to fuel utilisation and waste disposition. The MHR is able to burn all of the transuranic actinides from conventional LWR spent fuel, without requiring separation of the plutonium. The plutonium and

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172 Actinides are an element with atomic number of 89 (actinium) to 102. Usually applied to those above uranium - 93 up (also called transuranics). Actinides are radioactive and typically have long half-lives. They are therefore significant in wastes arising from nuclear fission, e.g. used fuel. They are fissionable in a fast reactor. Fission products are daughter nuclei resulting either from the fission of heavy elements such as uranium, or the radioactive decay of those primary daughters. These include caesium, iodine, strontium and xenon. Usually highly radioactive. See: World Nuclear Association (WNA), *Glossary*, WNA, London, December 2005, viewed 10 August 2006, <http://www.world-nuclear.org/info/inf51.htm#d>.

173 ASNO, *Exhibit no. 93, op. cit.*, p 11.

174 Professor Leslie Kemeny, *Exhibit no. 42, Emerging Nuclear Energy Systems – A One Hundred Year Perspective*, p. 5; Professor Leslie Kemeny, *Exhibit no. 38, Stochastic Techniques for the Control and Surveillance of a Modular Pebble Bed Reactor, p. 1.* See also: M LaBar, *The Gas Turbine-Modular Helium Reactor: A Promising Option for Near Term Deployment*, GA, San Diego, 2002, p. 8, viewed 30 August 2006, <http://gt-mhr.ga.com/summary_all.html>.

transuranics are destroyed in the deep burn MHR. This reduces the volume of residual waste requiring disposal in repositories.[175]

The Global Nuclear Energy Partnership

7.162 In February 2006 the US Government announced a Global Nuclear Energy Partnership (GNEP) initiative which seeks to develop a worldwide consensus on enabling expanded use of nuclear energy through the deployment of a fuel cycle that enhances energy security, while promoting non-proliferation.[176]

7.163 As currently proposed, GNEP has the following key features:

- 'Fuel supplier nations' would undertake to supply 'user nations' with reactors, and to supply nuclear fuel on a 'cradle-to-grave' basis. This would include spent fuel take-back—users could return spent fuel to the fuel supplier, who would recycle the fuel and treat the eventual high level waste (HLW). HLW is most likely to be returned to the user, but because of the reduced isolation period HLW will be easier to manage than currently—instead of deep geologic disposal, above-ground storage and eventual shallow burial could be satisfactory.
- User nations, in return for these supply commitments, would undertake not to develop enrichment or reprocessing. The initiative envisages users will operate conventional LWRs, will lease LEU fuel from suppliers, and return the spent fuel to suppliers.
- Fuel supplier nations would operate FNRs and advanced spent fuel separation, in order to recycle plutonium and transmute longer-lived radioactive materials formed in spent fuel to shorter-lived elements. Advanced spent fuel separation differs from current reprocessing in that plutonium is not fully separated, but remains mixed with uranium and highly radioactive materials. Transmuting the longer-lived materials reduces the period HLW has to be isolated from the environment, from some 10,000 years to 300-500 years.[177]

7.164 In essence, GNEP envisages that those countries with advanced nuclear capabilities (the five NWS plus Japan) will provide fuel services (supply and recovery of used fuel) to other nations who agree to use nuclear energy for power generation purposes only and to forego uranium

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175 GA, *Exhibit no. 80, Sustainable Long Term Nuclear Power: Destruction of Nuclear Waste and Recycle of Resources for the long run using MHR Deep Burn Technology and Fusion*, slide 25; ASNO, *Exhibit no. 93, op. cit.*, p. 5. See also: GA, *GT-MHR Plant Description*, viewed 11 August 2006, <http://gt-mhr.ga.com/1simpl_all.html>.

176 See: DOE, *The Global Nuclear Energy Partnership*, p. 1, viewed 10 August 2006, <http://www.gnep.energy.gov/>.

177 ASNO, *Exhibit no. 93, op. cit.*, p. 2.

enrichment and reprocessing activities. The supplier nations will fabricate and lease fuel for conventional reactors, with the used fuel being returned to the supplier countries and reprocessed to recover uranium and actinides, leaving only fission products as high-level waste. The actinide mix is then burned in on-site fast reactors known as advanced burner reactors (ABRs), or 'plutonium burning reactors', which consume plutonium and other long-lived radioactive material.[178]

7.165 The UIC reports that the two significant new technical elements in GNEP are new reprocessing technologies which separate all transuranic elements together (and not plutonium on its own), starting with a laboratory–proven reprocessing technology known as 'UREX+' and eventually moving to a pyroelectrolytic process, and the development of ABRs which can consume the resulting plutonium/uranium and actinide mix and do not produce weapons useable plutonium.[179]

7.166 In addition, GNEP will support an expanded program to design and deploy small scale nuclear reactors that are suited to conditions in developing nations, and will also seek to incorporate advanced safeguards approaches into the planning and building of power plants and fuel cycle facilities.[180]

7.167 ASNO explained that GNEP seeks to bring together in a coherent program several technical proposals which have been under development in several countries over a number of decades. In addition to addressing proliferation concerns and allowing for greater utilisation of uranium resources, the initiative also promises to reduce the quantity of HLW, thus reducing storage requirements by up to 90 percent. Moreover, the isolation period for the HLW will be significantly shortened.[181]

7.168 It was submitted that GNEP will benefit non-proliferation objectives by limiting the spread of enrichment and reprocessing, reducing the holdings of plutonium-bearing spent fuel and it would enable the use of plutonium

178 UIC, *Fast Neutron Reactors, loc. cit.*

179 Transuranic elements are very heavy elements formed artificially by neutron capture and possibly subsequent beta decay(s). The have a higher atomic number than uranium (92). All are radioactive. Neptunium, plutonium, americium and curium are the best-known. All commercial reprocessing plants use the PUREX process (Plutonium Uranium Extraction Process) which separates a stream of plutonium and a stream of uranium from the waste stream containing both transuranics and fission products. UREX (Uranium Reduction and Extraction) separates only uranium, then keeps the plutonium with transuranics and separates both from shorter-lived fission products. The UREX+ process separates a mixed uranium-plutonium stream from a transuranic stream and fission product streams. UIC, *Newsletter*, Issue 2, 2006, March/April 2006, p. 2, available online, viewed 10 August 2006, <http://www.uic.com.au/news206.pdf>.

180 DOE, *The Global Nuclear Energy Partnership*, *op. cit.*, p.4.

181 ASNO, *Exhibit no. 93, op. cit.*, p. 1.

fuels without production of separated plutonium. ASNO explained that GNEP is of significance because the US, which has opposed reprocessing since the Carter Administration because of proliferation dangers, now recognises that plutonium recycle offers advantages for efficient uranium utilisation and spent fuel management. It also involves funding (US$150 million for the first year) that will enable the US to take a technological lead and is providing focus and leadership for international collaboration in developing advanced fuel cycle technologies. However, as the project has only recently been launched, it can be expected to evolve over time.[182]

Australia's contribution to the non-proliferation regime

7.169 ASNO and the UIC described Australia's significant contribution to the development of the non-proliferation regime. For example, in the 1960s Australia participated in the drafting of the IAEA's Statute and, since then, has been continuously represented on its Board of Governors.[183]

7.170 An Inquiry conducted in 1984 by the Australian Science and Technology Council (ASTEC), *Australia's Role in the Nuclear Fuel Cycle*, also found that Australia's voice has been strong in non-proliferation debates and that Australian initiatives have helped to strengthen the regime. It was found that Australia's voice is heeded in part because of the considerable reserves of uranium Australia possesses. ASTEC concluded that through 'active involvement in the nuclear fuel cycle' Australia will be able to 'further advance the cause of nuclear non-proliferation.'[184] However, it was also concluded that:

> …without such involvement … global energy security would be less assured and our ability to strengthen the non-proliferation regime and to influence the future developments in the fuel cycle would be reduced. We do not wish to exaggerate Australia's role in matters related to the nuclear fuel cycle but we are convinced that it is only by active involvement that Australia can expect to be able to influence the future course of events.[185]

7.171 AMEC and the UIC also argued that Australia's position as a major uranium exporter assists the nation to influence the ongoing development of non-proliferation measures and to exert influence in international nuclear issues:

182 *ibid*.
183 UIC, *Submission no. 12*, p. 31.
184 ASTEC, *Australia's Role in the Nuclear Fuel Cycle*, *op. cit.*, pp. 135–136.
185 *ibid*., p. 136.

> … with the extent of the world's uranium resources it controls, Australia is uniquely placed to exercise even greater international influence to maintain the safety and security of the nuclear fuel cycle.[186]

7.172 Similarly, ASNO observed that: 'Our position as a major uranium exporter gives us both the responsibility and the standing to pursue these issues effectively'.[187]

7.173 ASNO submitted that Australia is currently playing a major role in efforts to strengthen the non-proliferation regime, including in such bodies as the IAEA Board of Governors and the NSG. Australia is also active in bilateral and regional efforts to strengthen the non-proliferation regime. Examples of the areas where Australia is active include the following:

- Australia chairs the Vienna-based Group of 10 (G-10) countries who are like-minded on the NPT's vital security benefits. The G-10 meets informally prior to each NPT meeting.[188]
- As a member of the NSG, Australia participates in its plenary meetings including the meeting held in June 2005 at which the NSG adopted measures to further strengthen nuclear export controls, including:
  - ⇒ procedures for suspending nuclear transfers to countries that are non-compliant with their safeguards agreements;
  - ⇒ measures to evoke fall-back safeguards if the IAEA can no longer undertake its safeguards mandate in the recipient state; and
  - ⇒ making export controls in the recipient state a criterion of supply.

  The NSG plenary agreed to continue discussions on the AP as a condition of supply and on further strengthening of the NSG guidelines with respect to enrichment and reprocessing technologies.
- Australia pursues diplomatic efforts through the IAEA Board of Governors and through Australia's bilateral/multilateral contacts. Australia's nuclear science program, and its position as a major uranium exporter, gives Australia a permanent seat on the IAEA Board of Governors and substantial influence in international nuclear issues.
- Australia has advocated firm action by the IAEA against safeguards non-compliance. Australia has consistently supported resolutions in the IAEA Board of Governors on Iran's nuclear program and has urged Iran to comply with these resolutions. Australia supported the Board's

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186 UIC, *op. cit.*, p. 3. See also: AMEC, *loc. cit*; The Hon Alexander Downer MP, *Submission no. 33*, p. 4.

187 The Hon Alexander Downer MP, *Submission no. 33*, p. 3.

188 The G-10 countries are Australia, Austria, Canada, Denmark, Hungary, Ireland, the Netherlands, New Zealand, Norway and Sweden.

4 February 2006 resolution reporting Iran's safeguards non-compliance to the UN Security Council.

- Australia is working to strengthen verification of NPT non-proliferation commitments. Australia strongly supported establishment of the IAEA Board's safeguards and verification committee and is participating actively in its work. ASNO's Director General, Mr John Carlson, chairs the IAEA Standing Advisory Group on Safeguards Implementation (SAGSI). SAGSI is at the forefront in developing new safeguards approaches and methods.
- Australia is working to secure wider application of the IAEA safeguards strengthening AP, consistent with the prominent role Australia played in development of the IAEA's strengthened safeguards system. Australia is working with the IAEA and other countries to increase the number of APs in force, in particular through outreach and assistance to states in the region. As noted, Australia was the first country to sign and ratify an AP (in 1997) and in 2005 Minister Downer announced that Australia will make the AP a pre-condition for the supply of uranium to NNWS.
- Australia provides technical support to the IAEA through trialling of new safeguards approaches and methods in Australia, through a formal Safeguards Support Program covering safeguards R&D projects, and through making analytical and other capabilities of ANSTO available to the IAEA.
- Australia is a strong advocate of the CPPNM and was an active contributor in negotiations on amendments to the CPPNM to extend its application. Australia chaired the main committee at the July 2005 diplomatic conference to amend the CPPNM. Australia is increasing its efforts to encourage countries in the region to accede to the amended CPPNM.
- On 26 July 2005 Mr Downer joined with the Foreign Ministers of Chile, Indonesia, Norway, Romania, South Africa and the United Kingdom in issuing a joint declaration on nuclear non-proliferation and disarmament. The aim of this initiative was to stimulate a strong outcome on these issues at the UN Summit in September 2005. Australia chaired the consultations on the non-proliferation and disarmament component of the 2005 UN Summit draft outcomes document. Regrettably, the Summit was unable to reach agreement on these issues. However, the seven country group is considering possible further initiatives on these issues.
- Australia continues to work for the CTBT's entry into force. In September 2005, Mr Downer chaired a conference of CTBT parties on

ways to accelerate the Treaty's entry into force. As the current coordinator of CTBT parties' efforts to promote entry into force, Australia has a special role in urging countries in our region and elsewhere to ratify the CTBT as soon as possible. Australia welcomed Vietnam's recent ratification of the CTBT.

- Australia is making a significant contribution to the establishment of the CTBT's International Monitoring System (IMS) to verify that CTBT parties comply with their commitments. In addition to the 21 IMS facilities Australia will host, Australia contributes to the work of the CTBT PrepCom on development of the IMS. An Australian is currently Task Leader for the elaboration of the CTBT On-Site Inspection Operational Manual.
- At the 2005 UN General Assembly First Committee Australia supported key nuclear non-proliferation and disarmament related resolutions. In particular, Australia worked closely with Japan on its nuclear disarmament resolution and was an original sponsor of this resolution. Other nuclear related resolutions supported by Australia included those on the CTBT and on the negotiation of a Fissile Material Cut-off Treaty (FMCT) to end the production of fissile material for nuclear weapons.
- Australia is currently undertaking a three-year regional program to increase engagement with regional countries on WMD counter-proliferation. This program tailors practical assistance to local needs, including advice on the development of export control legislation and control lists, the conduct of industry outreach and licensing and enforcement training for officials.
- Australia continues to strongly support the PSI. A priority for Australia, and for other PSI participants, is to maintain and refine capabilities for interdicting WMD-related trade. Australia hosted its second multi-nation PSI exercise in Darwin in April 2006 focusing on air/ground interdiction. Australia hosted the first ever PSI exercise in 2003 and has also hosted two major PSI meetings.[189]

189 The Hon Alexander Downer MP, *Submission no. 33.4*, pp. 2–4; The Hon Alexander Downer MP, *Submission no. 33.2*, p. 7.

Conclusions

7.174 The Committee concludes that the global safeguards regime has indeed been remarkably successful in limiting the proliferation of nuclear weapons. Today, in addition to the five nuclear-armed states that existed prior to the NPT's entry into force in 1970, there are only four states that have or are believed to have nuclear weapons: the three non-NPT parties—Israel, India and Pakistan—and North Korea. This is clearly a tremendous achievement, particularly in light of predictions that by the end of the 20th century there would be some 25 to 30 nuclear armed states.

7.175 The key treaty and institutional elements of the non-proliferation regime have been the NPT and the safeguards measures of the IAEA. The regime has been supported and reinforced by a range of complementary measures, such as multilateral efforts to control the export of sensitive technologies and materials.

7.176 In response to the discovery of a clandestine weapons program in Iraq, which had a comprehensive safeguards agreement in force with the IAEA at the time, a range of safeguards strengthening measures have now been introduced. These measures enable the IAEA to draw conclusions about the absence of *undeclared* nuclear materials and activities in countries, in addition to the assurance provided under traditional safeguards about the non-diversion of *declared* nuclear material and activities. The Committee considers that these measures are clearly a great advance.

7.177 Central to the safeguards strengthening measures has been the adoption by states of an Additional Protocol to their safeguards agreements with the IAEA. APs require states to provide the IAEA with broader information, allow the IAEA wider access rights and enable it to use the most advanced verification technologies. The Committee is pleased to note the Australian Government's strong support for the AP, its prominent role in the AP's formulation and that Australia was the first country to sign and ratify an AP. The Committee also welcomes the Government's decision to make the AP a condition for the supply of uranium to NNWS. The Australian public will now be able to have greater assurance that Australian obligated nuclear material will not be diverted for use in weapons programs.

7.178 However, the Committee is concerned that the uptake of APs remains slow. As of July 2006, only 77 countries had APs in force. The Committee notes with concern the IAEA Director General's comment that the Agency's verification efforts will not be judged fully effective on a global scale as long as its access rights remain uneven. The AP must become the universal standard for verifying nuclear non-proliferation commitments. The Committee urges the Australian Government to redouble its efforts to encourage adoption APs by other countries.

7.179 A main criticism of nuclear power is that civil and weapons programs are said to be inextricably linked. The reason for this is that two technologies used to produce nuclear reactor fuel—uranium enrichment and plutonium separation (reprocessing of used reactor fuel)—can also be used to produce fissile material for weapons. This fact has long been recognised and is reflected in efforts to limit the spread of these proliferation-sensitive technologies.

7.180 Critics of nuclear power also argue that civil programs have preceded and facilitated development of nuclear weapons in those countries which possess them. However, evidence shows that countries with nuclear weapons developed them *before* they developed nuclear power programs, and in some of the weapon states nuclear power remains insignificant or non-existent.

7.181 Submitters alleged that there are a range of deficiencies and limitations to the NPT/IAEA safeguards regime. While the Committee believes that most of these alleged deficiencies are without substance, it notes that the non-proliferation regime is now facing several challenges. The Committee concurs with the Minister for Foreign Affairs that these challenges must be met so that the public can be confident that an expansion of nuclear power (and of uranium exports) will not represent a risk to international security.

7.182 Among these challenges is the weakening of political support for the non-proliferation regime, evidenced perhaps by the failure of the 2005 NPT Review Conference to agree on any final document. The Committee is concerned that some NNWS apparently perceive the current regime to be discriminatory, arguing that the NNWS are required to keep their non-proliferation commitments while, it is claimed, the NWS do not adhere to their disarmament obligations under the Treaty. A worrying trend seems to have emerged in which some countries focus exclusively on disarmament and nuclear technology acquisition, and use proliferation as a chip to be bargained with, thus neglecting the non-proliferation core of the Treaty.

7.183 This perspective clearly misses a key point—that adherence by all NNWS to nuclear non-proliferation commitments under the NPT is manifestly in the interests of those very same states. The NPT delivers all states vital security benefits. Moreover, the Committee agrees with ASNO that a stable non-proliferation environment and a firm commitment by all NNWS to non-proliferation are likely to be essential conditions for further nuclear disarmament. Furthermore, the Committee believes that that the very significant reductions in nuclear arsenals in the NWS to date must be acknowledged.

7.184 Another limitation to the IAEA's verification regime, now receiving international attention, relates to so-called 'parallel weaponisation' activities. While current safeguards agreements are expressed in terms of verification of nuclear material, certain weaponisation activities do not involve nuclear material and are dual use in nature. Currently, for the IAEA to investigate such activities, there has to be a clear nexus with nuclear material. The Committee believes that the verification regime must continue to develop so as to provide the IAEA with a right of access sufficient to investigate possible parallel weaponisation activities.

7.185 The Committee notes the expanded responsibility the IAEA now has with APs in force and the range of additional verification activities in which it may engage. The Committee shares submitters' concerns about the adequacy of the resourcing (financial, technological and staffing) for the IAEA's safeguards program. The Committee believes that the value of the assurance provided by the IAEA safeguards program far outweighs its cost and, in view of the likely expansion of nuclear power worldwide, believes that the IAEA must be adequately resourced to meet the increased demands. Notwithstanding the savings that may follow the wider development of integrated safeguards, the Committee urges the Australian Government to keep this matter under close observation and consider advocating within the IAEA for an increased safeguards program budget and increased contributions from IAEA member governments.

7.186 Another key challenge is the problem now presented by Iran, which claims the right to develop the *full* nuclear fuel cycle, ostensibly on the grounds of security of nuclear fuel supply. This raises the possibility that, having made full use of the alleged 'right' to acquire proliferation-sensitive technologies under Article IV of the Treaty, states could then withdraw from the NPT and pursue weapons programs.

7.187 The Committee notes that the claim of a right to pursue proliferation-sensitive technologies may indeed be a serious misreading of the Treaty, which speaks of the right of all parties to use *nuclear energy* for peaceful purposes and that this was never intended to mean development of *any* nuclear technology. It is clear that when the NPT was first negotiated it was envisaged that the NWS would provide these fuel cycle services to the NNWS. Moreover, the Committee notes that the right to use of nuclear energy is subject to the other provisions of the Treaty, notably the corresponding duties to comply with NPT and safeguards commitments—factors that seem to have been ignored by Iran and its supporters.

7.188 Nonetheless, the Committee is pleased to note that this dilemma is receiving considerable attention and that there are a range of proposals now being considered that will increase control over proliferation-sensitive technologies and limit their spread. ASNO has suggested:

- the development of criteria for assessing the international acceptability of proposed sensitive projects (this criteria could include factors such as the non-proliferation credentials of the country concerned, whether there is a clear economic/energy rationale, and whether the country is located in a region of tension);
- a more rigorous safeguards regime for countries with sensitive technologies;
- international guarantees of fuel supply for countries that forgo national enrichment and reprocessing capabilities; and
- possible establishment and operation of sensitive facilities on a multination basis.

7.189 An expert group appointed by the Director General of the IAEA has proposed a series of five multilateral approaches to the nuclear fuel cycle, including international supply guarantees, and multinational/regional operation of new nuclear facilities based on joint ownership, drawing rights or co-management.

7.190 The Committee notes ASNO's observation that Australia would have a limited capacity to take on a 'catalytic role' in forming a group of countries to advocate on behalf of the supply guarantee proposal. This is because supply guarantees relate more to enrichment and fuel fabrication services, rather than uranium supply. However, as ASNO notes, if countries choose to develop enrichment and reprocessing technologies despite being given long-term fuel supply guarantees this could well expose the real reasons for the country's actions. The Committee agrees with Mr Lance Joseph's observation that Australia does have a vested interest in seeing that the spread of proliferation-sensitive technologies remains limited. The Committee supports nuclear fuel supply guarantees for those countries who foreswear the right to develop enrichment and reprocessing technologies.

7.191 In view of the situation presented by Iran and other nations claiming the 'right' under Article IV of the NPT to develop any nuclear technology (including proliferation sensitive technologies), the Committee believes that the NPT should be renegotiated to address this ambiguity. The Committee also concludes that the framework proposed by ASNO and the incremental multilateral approaches proposed by the IAEA should be pursued.

7.192 While the Committee acknowledges that technical measures to prevent proliferation are unlikely to be successful in the absence of political commitment, the Committee is encouraged to note that proliferation-resistant technologies are continuing to be developed. In particular, the Committee was informed about efforts to develop a nuclear fuel cycle that does not require enrichment and currently-established reprocessing technologies (which separate out plutonium that could potentially be diverted for weapons), and the development of reactor types that incorporate proliferation resistance into their designs.

7.193 The Advanced Fuel Cycle Initiative and the Global Nuclear Energy Partnership project will allow for the recycling of plutonium, thereby extending significantly the energy that can be obtained from uranium, but without the dangers of plutonium separation. Furthermore, as noted in the chapter five, GNEP proposes that plutonium and much of the waste will be consumed in reactors deigned to burn this material, thereby reducing significantly the volume and toxicity of waste requiring final disposal. Should these concepts be developed and receive wide acceptance, the challenge to contain enrichment and reprocessing technologies will eventually end.

7.194 Finally, the Committee welcomes the commendable range of efforts the Australian Government is undertaking to advance non-proliferation objectives. As a major uranium exporter and, potentially, as the world’s largest uranium producer, Australia has a strong interest in ensuring that the material and technologies required for peaceful use of nuclear energy are not diverted for any military purpose. The following chapter considers the range of bilateral measures undertaken by the Australian government to ensure that such diversion does not occur.

Recommendation 4

The Committee recommends that the Minister for Foreign Affairs:

- **seek, through all relevant fora, to impress on other countries the central importance of the non-proliferation aspects of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) and the security benefits of the NPT for all countries;**
- **redouble efforts to encourage adoption by other countries of an Additional Protocol to their safeguards agreements with the International Atomic Energy Agency (IAEA);**
- **advocate strengthening the verification regime so that the IAEA is empowered to more thoroughly investigate possible parallel weaponisation activities;**
- **seek the development of criteria for assessing the international acceptability of proposed sensitive projects, particularly in regions of tension, and advocate the development of a more rigorous verification regime for countries that either possess or choose to develop sensitive facilities;**
- **support proposals for nuclear fuel supply guarantees for those countries who waive the right to develop enrichment and reprocessing technologies; and**
- **come to a considered view about the adequacy of the resources currently allocated to the IAEA's safeguards program and, if deemed necessary, advocate within the IAEA Board of Governors for an increased allocation of resources to verification activities and recommend increased contributions from member states.**

8

Australia’s bilateral safeguards

The stringency of Australia’s approach, ensuring Australian involvement in regulating for the full life of its nuclear material … is internationally recognised for the contribution it has made to ensuring such material is not diverted for military purposes. Australia retains the right to be selective regarding the countries with which it is prepared to conclude bilateral safeguards agreements. As such, and with the extent of the world’s uranium resources it controls, Australia is uniquely placed to exercise even greater influence to maintain the safety and security of the nuclear fuel cycle.[1]

1 Uranium Information Centre (UIC), *Submission no. 12*, p. 12.

Key messages —

- **In addition to the International Atomic Energy Agency (IAEA) safeguards described in the previous chapter, Australia imposes additional safeguards requirements on its uranium exports through a network of bilateral safeguards agreements.**
- **The objectives of Australia's safeguards policy are to ensure that Australian Obligated Nuclear Material (AONM) is: appropriately accounted for as it moves through the fuel cycle; is used only for peaceful purposes; and in no way contributes to any military purpose.**
- **Of the five cases where the IAEA has found countries to be in non-compliance with their safeguards agreements and reported the non-compliance to the UN Security Council, none of these cases involved countries eligible to use Australian uranium.**
- **While it cannot be absolutely guaranteed that diversion of AONM for use in weapons could never occur at some point in the future, nevertheless the Committee is satisfied that Australia's safeguards policy has been effective to date. The conditions in safeguards agreements are adequate and there is no reason to impose additional requirements on customer countries at this time.**
- **There is little or no potential for the diversion of AONM for use by terrorists, or for AONM and other radioactive material in Australia to be used in 'dirty bombs'. Australia's conditions for supply of AONM include an assurance that internationally agreed standards of physical security will be applied to nuclear materials in the country concerned.**
- **Conventions and guidelines to help protect against acts of nuclear terrorism have recently been strengthened, including significant amendments to the Convention on the Physical Protection of Nuclear Materials and the Code of Conduct for Safety and Security of Radioactive Sources.**
- **The Committee is pleased to note that Australia has again been at the forefront in negotiating these outcomes, as well as contributing to nuclear security initiatives in the region, such as leading a project to ensure the security of radioactive sources.**
- **The Committee supports the Australian Government's decision to permit exports of uranium to China, while noting that, as with the other bilateral safeguards agreeements, Australia may suspend or terminate sales of uranium should AONM be diverted for weapons programs.**

- **The US-India nuclear cooperation agreement will have a number of important non-proliferation benefits, including that it will expand the application of IAEA safeguards in India, and allow the IAEA enhanced access rights. The majority of India's nuclear activities will be under safeguards by 2014.**
- **It is conceivable that Australian uranium could be supplied to India, which is not a party to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), in a way that does not undermine the non-proliferation regime. Indeed, the Director General of the IAEA has welcomed the US-India agreement, stating that the agreement is a 'step forward towards universalistion of the international safeguards regime.'**
- **While there are sound reasons to allow an exception to Australia's exports policy in order to permit uranium sales to India, including its record as a non-proliferator, the Committee does not wish to make a recommendation on the matter.**
- **Maintaining the integrity of the non-proliferation regime must remain the top priority and guiding principle for Australia's uranium exports policy. Australia's actions must not undermine the non-proliferation regime and the fundamental importance of the NPT—particularly given Australia's place as a major uranium producer. For the long-term stability and reputation of the Australian uranium industry, a bipartisan position on the India question should, if at all possible, be developed.**

Introduction

8.1 In this chapter the Committee considers the adequacy and effectiveness of Australia's safeguards policy and the bilateral safeguards agreements it enters into with countries wishing to purchase Australian uranium.

8.2 The chapter commences with an overview of the safeguards policy and the principal conditions for the use of Australian obligated nuclear material (AONM) set out in the bilateral agreements.

8.3 Four main criticisms were made of the safeguards policy and agreements, which the Committee considers in turn, along with rebuttals from the Australian Safeguards and Non-Proliferation Office. These criticisms related to:

- the quantity, complexity of chemical forms, and the variety of locations and circumstances in which Australia's exported uranium is held;

- accounting procedures for nuclear materials involve uncertainties and margins of error which, on the industrial scale involved, means that it cannot be excluded that material sufficient to produce a nuclear weapon(s) could be diverted;
- before comprehensive International Atomic Energy Agency (IAEA) safeguards were imposed on the international uranium trade, Australia sold several tonnes of unsafeguarded uranium to France, India and Japan in the 1960s; and
- since their inception under the Fraser Government, Australia's safeguards have been eroded by being inappropriately modified to accommodate commercial demands.

8.4 The Committee then considers several other proliferation concerns and allegations raised by submitters:

- Australia's uranium exports could free up indigenous sources of uranium in customer countries for use in their military programs;
- reprocessing of spent fuel containing AONM and the storage of Australian-obligated plutonium;
- Australian SILEX enrichment technology; and
- issues associated with export of uranium to China and, potentially, to India.

8.5 The chapter concludes with a discussion of nuclear security, including the possible malicious use of radioactive sources in so-called 'dirty bombs' and efforts to prevent nuclear terrorism.

Australia's safeguards policy

8.6 The principles underlying Australia's nuclear safeguards policy were developed following the publication in 1976 of the First Report of the Ranger Uranium Environmental Inquiry, which was a major Commonwealth Government inquiry under Justice R W Fox (the Fox report) that took place between 1975 and 1977.

8.7 The Fox report emphasised the importance of adequate safeguards measures being applied to Australia's uranium.[2] One of the principal findings of the report was that 'No sales of Australian uranium should take place to any country not party to the NPT' and that uranium exports

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2 See: Mr R W Fox, *Ranger Uranium Environmental Inquiry – First Report*, AGPS, Canberra, 1976, pp. 115–149; 185; Uranium Information Centre (UIC), *Submission no. 12*, p. 31.

'should be subject to the fullest and most effective safeguards agreements.'[3]

8.8 Australia's safeguards policy, which was announced on 24 May 1977, provides assurances that exported uranium and its derivatives cannot benefit the development of nuclear weapons or be used in other military programs. This is done by accounting for amounts of Australian Obligated Nuclear Material (AONM) as it moves through the nuclear fuel cycle.[4] The policy ensures that uranium exports are made only to selected countries covered by a bilateral safeguards agreement between Australia and the country concerned. Australia's requirements, set out in the bilateral agreements, are outlined below.

8.9 The objectives of Australia's safeguards requirements are to ensure that AONM:

- is appropriately accounted for as it moves through the nuclear fuel cycle;
- is used only for peaceful purposes in accordance with the applicable agreements; and
- in no way enhances or contributes to any military process.[5]

8.10 Australia's safeguards requirements are superimposed on and compliment the IAEA safeguards, which provide the basic assurance that nuclear material is not being diverted from peaceful to non-peaceful purposes. The UIC observed that:

> The legally-binding bilateral safeguard measures are directed towards preventing any unauthorised or clandestine use of exported uranium or any materials derived from it … They are designed to deter possible diversion of fissile material or misuse of equipment and technology more effectively than standard IAEA safeguards on their own.[6]

8.11 Whereas IAEA safeguards are generally not concerned with origin attribution, that is, the 'national flag' and conditions attached by suppliers (for the IAEA there are limited exceptions, e.g. under certain non-NPT safeguards agreements), this is the purpose of bilateral safeguards agreements. Australia's bilateral agreements specify conditions which are

3 Cited in Hon Alexander Downer MP, *Submission no. 33*, p. 10.

4 AONM is defined as Australian uranium and nuclear material derived therefrom, which is subject to obligations pursuant to Australia's bilateral safeguards agreements. Australian Safeguards and Non-Proliferation Office (ASNO), *Australia's Uranium Exports Policy*, viewed 17 July 2006, <http://www.dfat.gov.au/security/aus_uran_exp_policy.html>.

5 The Hon Alexander Downer MP, *Submission no. 33*, p. 13.

6 UIC, *op. cit.*, p. 32.

additional to IAEA safeguards, for example, with regard to retransfers, high enrichment and reprocessing of AONM.[7]

8.12 Australia's safeguards policy establishes the following criteria for the selection of countries eligible to receive AONM:

- non-nuclear weapon states (NNWS) must be a party to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) and meet the NPT full scope safeguards standard; that is, International Atomic Energy Agency (IAEA) safeguards must apply to all existing and future nuclear activities;
- from May 2005, NNWS must now also make an Additional Protocol with the IAEA (providing for strengthened safeguards and described in the previous chapter) as a pre-condition for the supply of Australian uranium; and
- in the case of nuclear weapons states (NWS), there must be a treaty level assurance that AONM will be used only for peaceful purposes, and arrangements must be in place under which AONM is subject to that state's safeguards agreement with the IAEA (i.e. in NWS facilities where AONM may be used or processed, these facilities must be on the state's Voluntary Offer Agreement and can be selected by the IAEA for inspections).[8]

8.13 A basic requirement of Australia's policy is the conclusion of a safeguards agreement between Australia and the country concerned, setting out the various conditions which apply to AONM. The principal conditions for the use of AONM set out in the bilateral safeguards agreements are summarised as follows:

- an undertaking that AONM will be used only for peaceful purposes and will not be diverted to military or explosive purposes, and that IAEA safeguards will apply;[9]
- none of the following actions can take place without Australia's prior consent:
  - ⇒ transfers to third parties;
  - ⇒ enrichment to 20 per cent or more in the isotope uranium-235;
  - ⇒ reprocessing;[10]

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7 ASNO, *Australia's Uranium Exports Policy*, *loc. cit*.

8 The Hon Alexander Downer MP, *Submission no. 33*, p. 13.

9 In this context 'military purpose' means nuclear weapons, nuclear explosive devices, depleted uranium munitions and military nuclear propulsion systems.

10 Consent has been given in advance to reprocessing on a programmatic basis in the case of five Agreements: Euratom, France, Japan, Sweden and Switzerland.

- provision for fallback safeguards or contingency arrangements in case NPT or IAEA safeguards cease to apply in the country concerned;
- an assurance that internationally agreed standards of physical security will be applied to nuclear material in the country concerned;
- detailed 'administrative arrangements' between ASNO and its counterpart organisation, setting out the procedures to apply in accounting for AONM;
- regular consultations on the operation of the agreement; and
- provision for the removal of AONM in the event of a breach of the agreement.[11]

8.14 The safeguards agreements stipulate coverage of uranium exports by IAEA safeguards from the time they leave Australian ownership, and continuation of coverage by IAEA safeguards for the full life of the material or until it is legitimately removed from safeguards. Contracts for the export of Australian uranium are also required to contain a clause noting that the contract is subject to the relevant bilateral safeguards arrangement.[12]

8.15 Australia currently has a network of 19 bilateral agreements, covering 36 countries, and Taiwan.[13] These agreements are listed in table 8.1.

8.16 In addition to the agreements listed, in April 2006 Australia and China entered into a bilateral safeguards agreement on the transfer of nuclear material, whereby sales of uranium to China will now be permitted.[14] Australian uranium cannot be transferred to China until the agreement is in force and administrative arrangements have been concluded between ASNO and the China Atomic Energy Authority.[15]

8.17 Under the *Nuclear Non-Proliferation (Safeguards) Act 1987* (the Safeguards Act), ASNO is responsible for ensuring that exports of uranium take place only under the terms of the bilateral safeguards agreements, including conducting the relevant nuclear materials accountancy. Under the Safeguards Act ASNO is also responsible for: ensuring uranium produced in Australia is properly accounted for; ensuring effective control of uranium (including the physical protection of such material); and

11 The Hon Alexander Downer MP, *Submission no. 33*, pp. 13–14.

12 ASNO, *Australia's Uranium Exports Policy*, *loc. cit*.

13 25 of the countries making up this total are EU member states.

14 ASNO, *Agreement Between the Government of Australia and The Government of the People's Republic of China on the Transfer of Nuclear Material*, viewed 26 June 2006, <http://www.dfat.gov.au/geo/china/treaties/nuclear_material.html>.

15 ASNO, Australia-China Nuclear Material Transfer Agreement and Nuclear Cooperation Agreement, *Frequently Asked Questions*, viewed 17 July 2006, <http://www.dfat.gov.au/geo/china/treaties/faq.html#2>.

administering the agreement between Australia and the IAEA for the application of safeguards in Australia.[16]

Table 8.1 Australia's Bilateral Safeguards Agreements and their dates of entry into force

Country[i]	**Date of Entry into Force**
Republic of Korea (ROK)	2 May 1979
UK	24 July 1979
Finland	9 February 1980
USA	16 January 1981
Canada	9 March 1981
Sweden	22 May 1981
France	12 September 1981
Euratom[ii]	15 January 1982
Philippines[iii]	11 May 1982
Japan	17 August 1982
Switzerland	27 July 1988
Egypt[iii]	2 June 1989
Russian Federation[iv]	24 December 1990
Mexico	17 July 1992
New Zealand[v]	1 May 2000
Czech Republic	17 May 2002
USA covering supply to Taiwan	17 May 2002
Hungary	15 June 2002
Argentina	12 January 2005

Source The Hon Alexander Downer MP, *Submission no. 33*, p. 17.

Notes:

i This list does not include Australia's NPT safeguards agreement with the IAEA, concluded on 10 July 1974 (reproduced as Schedule 3 to the *Nuclear Non-Proliferation (Safeguards) Act 1987).* In addition to these Agreements, Australia also has an Exchange of Notes constituting an Agreement with Singapore Concerning Cooperation on the Physical Protection of Nuclear Materials, which entered into force on 15 December 1989. The texts of these Agreements are published in the Australian Treaty Series.

ii Euratom is the atomic energy agency of the European Union. Czech Republic, Finland, France, Hungary, Sweden and the UK are members of Euratom and AONM in these countries is covered by the Australia/Euratom Agreement.

iii In the case of Egypt and the Philippines, Administrative Arrangements pursuant to the Agreements have not been concluded, so in practice the Agreements have not yet entered into operation.

iv The Australia/Russia Agreement covers the processing (conversion, enrichment or fuel fabrication) of AONM in Russia on behalf of other partner countries, but does not permit the use of AONM by Russia.

v The Australia/New Zealand agreement covers the supply of uranium for non-nuclear use.

8.18 As described in the previous chapter, there have been five cases, all involving undeclared plutonium separation or enrichment activities, where the IAEA has found that the country concerned was in non-compliance with its safeguards agreement, and reported the non-compliance to the Security Council: Iraq in 1991, Romania in 1992, DPRK

16 The Hon Alexander Downer MP, *Submission no. 33*, p. 8.

in 1993, Libya in 2004 and Iran in 2007. None of these cases involved countries eligible to use Australian uranium, and none were operating nuclear power programs at the time.[17]

Criticisms of Australia's safeguards policy and agreements

8.19 Several submitters argued that, despite the existence of safeguards, complete accounting for the uses to which uranium is put once it leaves Australian shores is a difficult task, and that 'we have no way of knowing whether our uranium is being used in any military capacity.'[18]

8.20 These submitters argued that the Australian public cannot be assured that safeguards have prevented or will continue to prevent the diversion of AONM from civil to military uses.[19] For example, the Arid Lands Environment Centre (ALEC) asserted that:

> The idea that Australia can guarantee that its uranium is only ever used for peaceful purposes is patently false. No treaty or safeguard process has ever proven to be leak-proof.[20]

8.21 Four arguments were advanced for this contention:

- the quantity, complexity of chemical forms, and the variety of locations and circumstances in which Australia's exported uranium is held;
- accounting procedures for nuclear materials involve uncertainties and margins of error which, on the industrial scale involved, means that it cannot be excluded that material sufficient to produce a nuclear weapon(s) could be diverted;
- before comprehensive IAEA safeguards had been imposed on the international uranium trade, Australia sold several tonnes of unsafeguarded uranium to France, India and Japan in the 1960s; and
- since their inception under the Fraser Government, Australia's safeguards have been eroded by being inappropriately modified to accommodate commercial demands.

8.22 Friends of the Earth—Australia (FOE) was also critical of the fact that Australian policy only requires that the NNWS adhere to Additional Protocols and not the weapon states.[21]

17 *ibid.*, pp. 12–13.

18 Ms Rita Warleigh et. al., *Submission no. 83*, p. 1; Medical Association for the Prevention of War (MAPW) (Western Australian Branch), *Submission no. 8*, p. 5.

19 See for example: Dr Gavin Mudd, *Submission no. 27*, p. 7; APChem, *Submission no. 38*, p. 4.

20 Arid Lands Environment Centre Inc. (ALEC), *Submission no. 75*, p. 2.

8.23 These claims are summarised in the sections which follow. ASNO provided responses to each criticism of the adequacy and effectiveness of Australia's safeguards policy and the rebuttals are cited in the discussion of each issue. In general, ASNO observed that while AONM is fully accounted for and Australia's policies and practice on uranium supply seek to minimise the risk of diversion, it cannot of course be absolutely guaranteed that diversion could never occur in the future.[22]

The quantity, complexity of chemical forms and the variety of locations and circumstances in which exported uranium is held

8.24 Professor Richard Broinowski argued that AONM cannot be effectively safeguarded because of the quantity, complexity of chemical forms and the variety of locations and circumstances in which exported uranium is held.[23] It was argued that:

> Despite assurances of the Safeguards Office to the contrary, it is not credible that *none* of this material has been lost through accounting errors, illegally diverted, or otherwise mishandled without detection.[24]

8.25 ASNO responded that there is no basis for this assertion and that the factors listed (quantity, form, locations and 'circumstances') have no adverse effect on the ability to apply safeguards to nuclear material. It was argued that Australian safeguards requirements are built on IAEA safeguards. Each of Australia's bilateral partners, in accordance with its safeguards agreement with the IAEA, is required to maintain a national system for nuclear material accountancy and control, under which detailed data are recorded and updated for all safeguarded nuclear material. These records are based on specific batches or items of nuclear material (e.g. individually numbered fuel elements). The IAEA also has some 45 years experience verifying states' inventories of nuclear material—confirming whether actual nuclear material holdings correspond to declared inventories—through inspections, measurements, containment and surveillance, and so on.[25]

8.26 It was submitted that Australia's bilateral partners are required to maintain records which enable AONM to be identified. These records are based on the records maintained to meet IAEA requirements—the usual

21 FOE, *Submission no 52*, p. 22.

22 The Hon Alexander Downer MP, *Submission no. 33.1*, p. 2.

23 Professor Richard Broinowski, *Fact or Fission: the truth about Australia's nuclear ambitions*, Scribe Publications, Melbourne, 2003, p. 256.

24 *ibid.*, p. 257. Emphasis in original.

25 The Hon Alexander Downer MP, *Submission no. 33.1*, p. 7.

mechanism is to add to the IAEA *pro forma* an additional column in which safeguards obligation is recorded (e.g. 'A' or 'AUS' for Australian-obligated material). This enables specific batches of nuclear material to be identified as AONM.[26]

8.27 ASNO explained that facility operators in countries receiving Australian nuclear material are obliged to keep detailed accounts of all the Australian material going through their facilities. Nuclear material is identified in batches and whether there are any safeguards obligations on that batch of material. In some cases uranium producers have no requirements, which is referred to as unobligated material, while some intermediate countries impose a 'peaceful use' obligation but do not attempt to track the material as Australia and some other countries (such as Canada and the US) do. Mr John Carlson, the Director General of ASNO, explained that:

> At the facility there are very detailed records of each batch of material and whether or not that material has a safeguards obligation. The accounting records will follow that material through the entire fuel cycle as it goes from conversion to enrichment to fuel fabrication, into a reactor and then into a spent-fuel pond, and maybe through reprocessing for the recovery and recycling of plutonium. Part of the formulas we apply take account of plutonium production, of course, so that Australian obligated nuclear material not only means the uranium we originally exported in its various forms as it goes through different processes but also covers material that is generated by using that uranium.
>
> Our counterparts in the countries that are using Australian uranium prepare detailed reports to us of how much Australian obligated nuclear material there is at the different stages of the fuel cycle at different periods and how much material changed its form—for instance, became irradiated, produced plutonium, was enriched or whatever. We receive all of that information. We do a consistency check on it, cross-checking information from other countries. One of the features of the fuel cycle is that it is very international, such that there is a regular flow of material from country to country, so you can cross-check reports from one country against reports from another, and we also cross-check from our knowledge of the facilities involved. So we have our own appreciation of the burn-up in particular types of reactors, the plutonium production rates and so on, and we compare the

26 *ibid.*, pp. 7–8.

> reporting we get against our expectation of what should be happening in the country concerned.
>
> The end result is that we have very detailed figures on the disposition of Australian uranium, and we have not found that there are any major concerns about any of that material being improperly accounted for, disappearing or whatever. I have seen some of the so-called evidence you have been given about Australian material disappearing and so on. I can assure you that it has not happened.[27]

8.28 In its *Annual Report 2004–2005*, ASNO stated that all AONM is accounted for satisfactorily. On the basis of the IAEA's Safeguards Statement for 2004 and ASNO's analysis of reports and other information from counterparts overseas, ASNO concluded that no AONM was used for non-peaceful purposes in 2004–05. ASNO officers visited all major bilateral partners to reconcile the AONM accounts.[28] Table 8.2 summarises the disposition of AONM at 31 December 2004.

Table 8.2 Summary of AONM by category, quantity and location at 31 December 2004

Category	Location	Tonnes[i]
Depleted uranium	EU, Japan, ROK, US	74 143
Natural uranium	Canada, EU, Japan, ROK, US	19 311
Uranium in enrichment plants	EU, Japan, US	10 392
Low enriched uranium[ii]	Canada, EU, Japan, Mexico, ROK, Switzerland, US	9 598
Irradiated plutonium[iii]	Canda, EU, Japan, Mexico, ROK, Switzerland, US	86
Separated plutonium[iv]	EU, Japan	0.4
TOTAL		113 531

Source ASNO, *Annual Report 2004–2005*, p. 44.

Notes:

i All quantities are given as tonnes weight of the element uranium, plutonium or thorium.

ii An estimated 80–90 per cent of Australian obligated low enriched uranium is in the form of spent reactor fuel.

iii Almost all Australian obligated plutonium is irradiated, i.e. contained in irradiated power reactor fuel or plutonium reloaded in a power reactor following reprocessing.

iv Separated plutonium is plutonium recovered from reprocessing. The figure for separated plutonium is not accumulative, but fluctuates as plutonium is fabricated with uranium as mixed oxide (MOX) fuel and returned to reactors for further power generation. On return to reactors the plutonium returns to the 'irradiated plutonium' category. During 2004, 0.2 tonnes of plutonium was fabricated into MOX fuel and transferred to reactors.

27 Mr John Carlson (ASNO), *Transcript of Evidence*, 10 October 2005, p. 23.

28 ASNO, *Annual Report 2004–2005*, Commonwealth of Australia, Canberra, 2005, pp. 44–45.

Accounting procedures for nuclear materials cannot exclude the possibility that material sufficient to produce a nuclear weapon could be diverted

8.29 The MAPW (Victorian Branch) argued that:

> Accounting procedures for nuclear materials involve uncertainties and margins of error which, on the industrial scale involved, means that it cannot be excluded that material sufficient to produce one or more nuclear weapons could be diverted.[29]

8.30 ASNO's *Annual Report 2003–2004* explained how the accounting for AONM is undertaken. Australia's bilateral partners holding AONM are required to maintain detailed records of transactions involving AONM, and ASNO's counterpart organisations are required to submit regular reports, consent requests, transfer and receipt documentation to ASNO. ASNO accounts for AONM on the basis of information and knowledge including:

- reports from each bilateral partner;
- shipping and transfer documentation;
- calculations of process losses and nuclear consumption, and nuclear production;
- knowledge of the fuel cycle in each country;
- regular liaison with counterpart organisations and with industry; and
- reconciliation of any discrepancies with counterparts.[30]

8.31 ASNO responded to MAPW's allegation by observing that accounting procedures for nuclear materials can be very precise, depending on the form of the material. It was acknowledged that there are measurement uncertainties or margins of error for nuclear material in certain forms. Examples include plutonium in spent fuel, where the plutonium content is a calculated value which cannot be confirmed by precise measurement unless the plutonium is recovered by reprocessing, and nuclear material undergoing bulk processing (such as reprocessing, where fuel elements are dissolved and uranium and plutonium recovered).[31]

8.32 In these cases, conclusions on non-diversion of nuclear material are not based on accountancy alone. In addition to nuclear accounting, the IAEA uses surveillance and containment methods, e.g. cameras and radiation detectors covering process lines, possible withdrawal points, and exit points. Even if the quantities of nuclear material undergoing processing

29 MAPW (Victorian Branch), *Submission no. 30*, p. 3.

30 ASNO, *Annual Report 2003–2004*, Commonwealth of Australia, Canberra 2004, p. 116.

31 The Hon Alexander Downer MP, *Submission no. 33.1*, p. 8.

are not known precisely at a particular moment, these measures are said to provide assurance that no materials have been removed from the process.[32]

Sales of unsafeguarded uranium in the 1960s

8.33 Professor Broinowski argued in his book, *Fact or Fission*, that before comprehensive IAEA safeguards had been imposed on the international uranium trade, Australia sold several tonnes of unsafeguarded uranium to France, India and Japan in the 1960s. It was argued that some of this material may have 'ended up in French or Indian nuclear weapons, or in weapons research programs of countries or sub-national groups to which a portion of it may have been traded.'[33]

8.34 ASNO responded that Australia's current policies on uranium exports, including the current bilateral agreements and the concept of AONM, date from 1977. Obviously, uranium exports prior to that time were not covered by current policies.[34]

8.35 However, ASNO argued that Professor Broinowski's statement is incorrect in two respects. First, although comprehensive or full scope safeguards were introduced following entry into force of the NPT in 1970, IAEA safeguards pre-date the NPT, and in fact have existed since 1959. Before the NPT, IAEA safeguards applied on an 'item-specific' basis, i.e. to specified materials and facilities (and this is still the case in the countries not party to the NPT).

8.36 Second, ASNO argued that it is not correct that all exports prior to introduction of the current policies were 'unsafeguarded'. For example, uranium exports to Japan were covered by the 1972 Australia-Japan nuclear cooperation agreement, which required Australian uranium to be covered by IAEA safeguards (which at that time were 'item-specific') or by safeguards applied by Australia. The current Australia-Japan agreement, concluded in 1982, required nuclear material supplied by Australia under the 1972 agreement to be brought under the new agreement. ASNO also noted that *Fact or Fission* itself indicates that in the France and India cases these were only 'sample quantities', not the tonnes suggested.[35]

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32 *ibid*.

33 Professor Richard Broinowski, *Fact or Fission, op. cit.,* p. 255.

34 The Hon Alexander Downer MP, *Submission no. 33.1*, p. 8.

35 *ibid*.

Erosion of Australia's safeguards

8.37 Professor Broinowski argued that the package of bilateral safeguards adopted in 1977 were substantially modified over the following ten years in order to 'accommodate the demands of consumers and the anxieties of Australian uranium mining companies not to lose customers.'[36] It was argued that, as a consequence of the modifications, the safeguards were 'gutted of its potency'.[37]

8.38 The People for Nuclear Disarmament (NSW) asserted that as a result of these modifications:

> Any decision to increase uranium exportation from Australia will need to be undertaken with the expectation that these safeguards will fail, that some Australian uranium will go missing, and that the possibility that some Australian uranium will end up in a nuclear weapons program cannot be excluded.[38]

8.39 Professor Broinowski alleged that there have been seven modifications to Australia's policy and these have eroded Australia's safeguards and increased the likelihood that AONM could be used in nuclear weapons. It was also alleged that 'it is absolutely clear' that some Australian uranium has already gone into weapons programs.[39] The seven alleged modifications are considered in turn.

Sales of uranium to France prior to its becoming an NPT Party

8.40 In June 1977, sales of uranium were allowed to France, which had not then signed the NPT.[40]

8.41 ASNO responded that from the outset of the current policy (the policy announcement of 24 May 1977), the requirement for NPT membership applied *only* to NNWS, on the basis that the NPT would ensure full scope safeguards applied to all their nuclear activities. In the case of the existing nuclear weapon states (including France), the policy has always been that exports may be permitted to such states where they give assurances that AONM will be used for exclusively peaceful purposes and will be covered by IAEA safeguards. Thus, conclusion of a bilateral agreement with France was totally consistent with the 1977 policy.[41]

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36 Professor Richard Broinowski, *Fact or Fission, loc. cit.*

37 Professor Richard Broinowski, *Submission no. 72*, p. 2.

38 People for Nuclear Disarmament (NSW) Inc, *Submission no. 45*, p. 9.

39 Professor Richard Broinowski, *Transcript of Evidence*, 16 September 2005, p. 18.

40 Professor Richard Broinowski, *Submission no. 72*, p. 2.

41 The Hon Alexander Downer MP, *Submission no. 33.1*, p. 9.

Australian uranium no longer had to attract IAEA safeguards when leaving Australian ownership

8.42 In October 1977 Australian uranium no longer had to attract IAEA safeguards when leaving Australian ownership (because uranium is shipped from Australia as uranium oxide, which did not attract IAEA safeguards, rather than as uranium hexafluoride (UF_6), which did).[42]

8.43 ASNO responded that the 1977 announcement recognised that this requirement presented a practical problem—Australia exports uranium oxide concentrate (UOC), which is before the 'starting point' of safeguards. UOC exports are reported to the IAEA, and the IAEA confirms their receipt, but the full range of safeguards procedures do not apply until the uranium conversion stage, when UOC is processed into UF_6 or uranium tetrafluoride (UF_4). To give effect to this requirement would have required establishment of uranium conversion facilities in Australia, but there was no commercial interest in this. Accordingly this requirement was modified.

8.44 An Inquiry conducted in 1984 by the Australian Science and Technology Council (ASTEC), *Australia's Role in the Nuclear Fuel Cycle*, reviewed this requirement, and found that this modification did not weaken the policy. ASTEC concluded:

> Indeed, the original policy appears to have been based on a misconception that ownership gives additional safeguards control. In fact, safeguards control ... is independent of ownership.[43]

Pre-1977 sales of uranium to Japan were not subject to prior consent; subsequently prior consent was dropped altogether in favour of a 'program' approach

8.45 By October 1977 Japan was informed that Australia would not insist that uranium contracted for supply before that date must be subject to the prior consent rule on transfer, enrichment or reprocessing, and then in January 1981 Australia dropped the provision altogether in favour of a 'program' or 'toll' approach.[44]

8.46 ASNO responded that the 1977 policy was not intended to be retroactive. Not unreasonably, Japan argued that uranium supplied pre-1977 should not be subject to new conditions. However, as noted above, pre-1977 material was rolled into the 1982 Australia–Japan agreement.

42 Professor Richard Broinowski, *Submission no. 72*, p. 2.

43 ASTEC, *Australia's Role in the Nuclear Fuel Cycle*, AGPS, Canberra, 1984, p. 161.

44 Professor Richard Broinowski, *Submission no. 72*, p. 2.

8.47 As regards programmatic consent, ASNO argued that this does not represent a derogation from the requirement for consent. The requirement for consent is that prior written consent must be obtained from Australia before nuclear material is transferred to a third country, high enriched (to 20 per cent or more U-235), or reprocessed. Rather than process numerous individual consent applications, the government decided it was more convenient to all concerned to give generic consent in advance under circumstances where in any event individual consent would have been given. The conditions of such consents are carefully defined, and Australia can withdraw consent if there are any difficulties. ASNO argued that this is entirely consistent with the 1977 policy but simply makes for more efficient implementation.[45]

8.48 Under most of Australia's agreements, consent has been given in advance for transfers at the 'front-end' of the fuel cycle, i.e. prior to irradiation, from one Australian agreement partner to another in accordance with the conditions in the respective agreements. This is intended to save time and administrative work, compared with case-by-case approvals. These advance consents apply in circumstances where approval would have been given if consent had been requested on a case-by-case basis. Australia is free to revoke advance consents at any time if necessary.

8.49 As noted above, in some agreements advance consent has also been given for reprocessing to take place. These consents allow reprocessing and associated 'back-end' transfers (e.g. transfers of irradiated fuel and nuclear material recovered from reprocessing), in accordance with a fuel cycle program agreed with Australia, hence the term 'programmatic consent'. Here too consents are given only in circumstances where consent would be given if sought on a case-by-case basis, and Australia is free to revoke advance consents at any time if necessary. ASNO commented that:

> There has been some ill-informed comment that programmatic consent is a diminution of Australian conditions. This is untrue and simply demonstrates ignorance of how the bilateral agreements function.[46]

Allowing uranium contracts to be negotiated before conclusion of bilateral agreements

8.50 In January 1979 the Commonwealth Government permitted sales contracts to be negotiated before the negotiation of bilateral safeguards agreements.[47]

45 The Hon Alexander Downer MP, *Submission no. 33.1*, pp. 9–10.

46 The Hon Alexander Downer MP, *Submission no. 33*, p. 14.

47 Professor Richard Broinowski, *Submission no. 72*, p. 2.

8.51 ASNO responded that this issue was examined by the 1984 ASTEC Inquiry. ASTEC found that, rather than placing Australia under pressure to dilute its policy:

> … there is some evidence to suggest [this] ... placed pressure on the *customer* country to meet Australia's requirements and conclude an agreement so that deliveries might proceed.[48]

8.52 ASTEC concluded that the change in policy did not result in any detriment and, on balance, provided neither negotiating side with an advantage.[49]

Sales from off-shore warehouses

8.53 By November 1982 sales of uranium were permitted from offshore warehouses outside Australian jurisdiction and through offshore brokers.[50]

8.54 ASNO noted that the applicable safeguards arrangements, rather than ownership, determine how nuclear material can be transferred and used. Establishing an offshore inventory, e.g. at a uranium conversion plant, gives the producer the opportunity to move quickly to secure contracts. However, the safeguards authority of the country where the inventory is located will not permit transfers outside the terms of the applicable safeguards agreements.[51]

The principle of 'equivalence' and the practice of international 'flag swaps'

8.55 It was claimed that in 1986 the Hawke Government introduced two reforms which allegedly 'weakened the identity of Australian uranium held abroad, and thus Australian ability to ensure that our safeguards continued to attach to it.'[52] These reforms were:

- the principle of 'equivalence', by which:

> Australian uranium could in practice be used in all manner of unauthorised ways, provided only that an amount of uranium equivalent to the original shipment from Australia could be seen to be used in approved activities;[53] and

48 ASTEC, *op. cit.*, p. 162. Emphasis added.

49 *ibid.*

50 Professor Richard Broinowski, *Submission no. 72*, p. 2.

51 The Hon Alexander Downer MP, *Submission no. 33.1*, p. 10.

52 Professor Richard Broinowski, *Submission no. 72*, p. 3. See also: People for Nuclear Disarmament (NSW) Inc., *Submission no. 45*, p. 8.

53 *ibid.*

- the concept of 'flag swaps' or 'book transfers', 'by which Australian originating uranium could become American or French or some other nationality to save transport costs.'[54]

8.56 ASNO explained that uranium is a fungible commodity, which means that uranium atoms are indistinguishable from one another, and international nuclear practice is to attribute safeguards obligations to nuclear material on the basis of the principles of equivalence and proportionality, which are defined below.[55]

8.57 For Professor Broinowski, the fungible nature of uranium means that the commodity:

> … is like sugar or wheat or any other bulk commodity. It is very hard to trace once it leaves our country. It is subject now to so many technicalities—so many different forms of working it, enriching it, doing whatever you like with it—that … I have challenged the government to justify or to explain how it is that they keep claiming they can track every single gram of Australian uranium. They cannot. It is not possible. These safeguard modifications—all because of commercial considerations, all to make our own uranium more attractive to clients—have weakened the whole system.[56]

8.58 Likewise, MAPW (Victorian Branch) argued that nuclear materials accountancy cannot guarantee that atoms of Australian uranium have not and will not in the future be used in weapons programs:

> At any stage of enrichment, processing or fabrication, it is impossible to distinguish by any means uranium from one source from uranium from any other source. Accounting is 'virtual'—so-called 'flag-swapping' has been shown to be routine.[57]

8.59 ASNO responded that the principle of equivalence was *not* introduced in 1986 and that the basis of Professor Broinowski's claim is not clear, but presumably was prompted by a statement of that time discussing the equivalence principle.[58]

8.60 It was argued that the principle of equivalence, and the complementary principle of proportionality, have applied from the outset. These principles were apparently not specifically mentioned in the 1977

54 *ibid*. See also: Professor Richard Broinowski, *Transcript of Evidence*, *op. cit*., p. 18.

55 The Hon Alexander Downer MP, *Submission no. 33.3*, p. 1.

56 Professor Richard Broinowski, *Transcript of Evidence, op. cit.,* p. 23.

57 MAPW (Victorian Branch), *op. cit*., p. 3; Associate Professor Tilman Ruff (MAPW Victorian Branch), *Transcript of Evidence*, 19 August 2005, p. 24.

58 The Hon Alexander Downer, *Submission no. 33.1*, p. 10.

announcement because they are matters of technical detail. However, the principles are applied under all of Australia's bilateral agreements, starting with the first agreement, with the ROK, in 1979:

> Australian policy since its inception in the seventies is that uranium is interchangeable. I have seen some of the witness statements … claiming that the policy has changed, but this was always part of the policy and it has always been part of international practice. That is what is called the principle of equivalence. Any batch of uranium of the same quality is the same as any other batch of the same quality. What is described as Australian obligated nuclear material is a way of identifying a batch of uranium as it goes through the fuel cycle and ensuring that that batch is covered at all times by the treaty commitments which ensure that it does not go into non-peaceful use.[59]

8.61 As noted above, the basis of the equivalence and proportionality conventions is that uranium is a fungible commodity, i.e. any particular quantity of uranium is indistinguishable from any other uranium of the same quantity and quality. It is a feature of the nuclear fuel cycle that uranium from different sources is mixed together at the various processing stages, e.g. conversion, enrichment, fuel fabrication, irradiation and reprocessing.

8.62 ASNO explained that this feature of the fuel cycle makes it impossible to track 'national atoms', and no country attempts to do this. Instead, at each stage of the fuel cycle an Australian obligation applies to the proportion of output that corresponds to the proportion of Australian-obligated input. The ASNO *Annual Report 2003–2004* defined the two principles further:

> The equivalence principle provides that where AONM loses its separate identity because of process characteristics (e.g. mixing), an equivalent quantity is designated AONM, based on the fact that atoms or molecules of the same substance are indistinguishable ... the principle of equivalence does not permit substitution by a lower quality of material …
>
> The proportionality principle provides that where AONM is mixed with other nuclear material, and is processed or irradiated, a proportion of the resulting material will be regarded as AONM corresponding to the same proportion as was AONM initially.[60]

8.63 ASNO stressed that because uranium is a fungible commodity tracking individual atoms of Australian uranium is impossible:

59 Mr John Carlson, *op. cit.*, p. 22.

60 ASNO, *Annual Report 2003–2004*, *op. cit.*, p. 115.

> … anti-nuclear activists feel that we should have a way of controlling atoms—that uranium produced in Australia should somehow be designated as Australian and that the batches of material should then be controlled through their life until they return to Australia or whatever. In fact, the nuclear industry does not attempt to work that way. Uranium is what is described as a fungible material. That means that any atom of uranium is indistinguishable from any other atom of uranium, and quite early in the fuel cycle process uranium from all different sources gets mixed. At the uranium conversion stage, where yellowcake is processed into uranium hexafluoride, which is the feed material for enrichment, the normal commercial process is that uranium from several different producers will be mixed together as it goes through the plant. So trying to track atoms in those circumstances is impossible. The only way we could maintain control over atoms would be to set up the entire fuel cycle in Australia and do what the former Soviet Union used to do—lease fuel elements to countries with reactors and take the fuel elements back.[61]

8.64 While it is theoretically possible that Australian uranium atoms might have gone into weapons:

> … in practice most weapons states operate civil facilities that are quite separate from military ones. The only point where atoms could jump from military to civil would be at the conversion stage—for instance, where there might be military material and civil material going through a conversion plant together and then you have a civil stream and a military stream coming out, and maybe in enrichment a similar situation.[62]

8.65 However, Mr Carlson argued that most of the weapon states never mixed material in this way; either the civil and military facilities were entirely separate, or they operated civil facilities on a campaign basis:

> … where they would run a plant for civil purposes, shut it down, clean everything out, put a batch of military material through and then clean that out and reopen it for civil use.[63]

8.66 Moreover, ASNO explained that:

> Even if at some point AONM is co-mingled with nuclear material that is not covered by safeguards obligations, the presence of the

61 Mr John Carlson, *op. cit.*, pp. 21–22.

62 Mr John Carlson, *op. cit.*, p. 22.

63 *ibid*.

> AONM in no way benefits or contributes to the quantity or quality of the unobligated material.[64]

8.67 In relation to the risk of diversion of AONM in the NWS, ASNO argued that the uranium needs for the civil nuclear programs in each of the countries greatly outweigh the requirements for any military production. Moreover, in the early 1990s four of the NWS (UK, USA, France and the Russian Federation) announced that production of fissile material for nuclear weapons purposes had ceased. ASNO noted that unclassified sources indicate that China also ceased production of fissile material for weapons in the early 1990s. There is no AONM in Russia. Finally, all the NWS provide Australia with detailed reporting on the disposition and use of AONM. These measures are said to provide assurance that the AONM within their jurisdiction remains exclusively in peaceful use.[65]

8.68 The Committee notes that on the issue of supplying uranium to the NWS, the Fox Inquiry report concluded that:

> Selling them uranium would not be likely to increase proliferation, even if they were to use it for military purposes ... It is possible that considerations of our own defence might in any event outweigh any factors adverse to the supply to those countries of our uranium.[66]

8.69 In relation to international 'flag swaps', ASNO explained that the basis of this practice is that, where a physical transfer might take place, in appropriate circumstances the physical transfer can be avoided (with resulting savings in terms of cost and the need to handle nuclear material). Professor Broinowski gives an example that illustrates these arrangements. Suppose:

(a) a US utility owns 100 tonnes of AONM in the form of UF_6 which is located in France awaiting enrichment. In the normal course, once enriched, the AONM will be shipped across the Atlantic for delivery to the US owner;

(b) a German utility owns 100 tonnes of South African uranium as UF_6 which is located in the US awaiting enrichment;

(c) the two companies could arrange to sell and transfer the uranium to each other, i.e. the US company would end up with 100 tonnes of South African uranium and the German company would have 100 tonnes of AONM. There would be no Australian policy issue with such transfers;

64 The Hon Alexander Downer MP, *Submission no. 33.3*, p. 1.

65 *ibid.*, p. 2; The Hon Alexander Downer MP, *Submission no. 33*, p. 14.

66 Mr R W Fox, *op. cit.*, p. 179.

(d) however, the companies can save shipping costs by arranging a 'book transfer', by which the AONM would be re-labelled as South African and the South African uranium would be re-labelled as AONM. The outcome would be the same as if a physical transfer had taken place.[67]

8.70 ASNO argued that there is no detriment to Australian policy from a transfer of this kind. Such transfers are said to be infrequent, are handled carefully by ASNO, and must reflect what could otherwise be done physically.[68]

8.71 ASTEC stated that it was satisfied:

> … overall that [Australia's bilateral] agreements meet the policy requirements and that those requirements are sufficiently comprehensive to provide as much control as can be realistically expected. We consider that Australian uranium and nuclear material derived from it are adequately accounted for and that Australia has the best possible guarantees that such material is being used solely within the civil nuclear programs of Australian customer countries.[69]

8.72 ASTEC also found that 'additional safeguards requirements … would serve only to compound the commercial and administrative burden, without improving safeguards controls or assurances.'[70]

8.73 Moreover, and in contrast to view of submitters who claimed that further uranium mining will contribute to proliferation, ASTEC concluded that 'this is not the case and … the risks of proliferation will be reduced.'[71] It was concluded that imposition of stringent safeguards 'may encourage other suppliers, of nuclear equipment as well as of uranium, to insist on comparable conditions', and that exports of uranium should not be curtailed provided that these stringent conditions of supply are observed.[72]

8.74 The Committee now turns to discuss several other proliferation concerns raised by submitters, namely that:

- Australia's uranium exports could free up indigenous sources of uranium in customer countries for use in their military programs;

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67 The Hon Alexander Downer MP, *Submission no. 33.1*, p. 10–11.

68 *ibid.*, p. 11.

69 ASTEC, *Australia's Role in the Nuclear Fuel Cycle*, AGPS, Canberra, 1984, p. 17.

70 *ibid.*

71 *ibid.*, p. 5.

72 *ibid.*

- reprocessing of spent fuel containing AONM and the storage of Australian-obligated plutonium;
- Australian SILEX enrichment technology; and
- issues associated with export of uranium to China and, potentially, to India.

8.75 The chapter concludes with a discussion of nuclear security, including the possible malicious use of radioactive sources in so-called 'dirty bombs' and efforts to prevent nuclear terrorism.

Australian uranium exports could free up indigenous sources of uranium for use in military programs in customer countries

8.76 It was argued by FOE, MAPW (Victorian Branch) and others that, even if Australian uranium is not diverted and used directly in military programs, Australia's uranium exports could potentially free up indigenous sources of uranium for use in military programs in customer countries.[73]

8.77 The Environment Centre of the Northern Territory (ECNT) argued that exports of uranium to China will:

> … simply displace their uranium from being used in nuclear power stations. They will put their uranium in the weapons and our uranium in the reactors. So, directly or indirectly, we are going to contribute—we are already contributing—to the proliferation of nuclear weapons around the world.[74]

8.78 ASNO responded that this argument has no basis and assumes that uranium is a scarce commodity. It was argued that in fact every country has uranium—if cost is no object it can even be recovered from seawater. It was therefore not a question of military and civil programs competing for uranium; historically, in the NWS, the military programs have always had priority and have been separately sourced.[75]

8.79 ASNO made the further point that all the NWS ceased production of fissile material for nuclear weapons purposes in the 1980s or 1990s. It is understood that, in China's case, the country has a sizeable stockpile of weapons-grade fissile material it is able to draw on if required.[76] The choice for a NWS is not, will it use uranium for weapons or for electricity,

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73 See: FOE, *Submission no. 52*, p. 20 and *Submission no. 52.2*, p. 11; MAPW (Victorian Branch), *op. cit.*, p. 3; MAPW (WA Branch), *Submission no. 8*, p. 5.

74 Mr Peter Robertson (ECNT), *Transcript of Evidence*, 24 October 2005, p. 10.

75 The Hon Alexander Downer MP, *Submission no. 33.1*, p. 11.

76 The Hon Alexander Downer MP, *Submission no. 33.3*, p. 2

but rather, will it generate baseload electricity with nuclear, coal, gas or hydro:

> … it is useful to put into perspective the suggestion that supply of uranium to a nuclear weapon state frees up indigenous uranium for nuclear weapons programs. The quantities of uranium required for a nuclear weapons program are relatively small, as little as five tonnes of natural uranium to produce one nuclear weapon. Such quantities of uranium are readily available in the nuclear weapon states. By contrast, producing fuel for one 1,000 megawatt power reactor requires around 200 tonnes of natural uranium every year. China's currently announced nuclear power program - 40,000 megawatts by 2020 - will require around 8,000 tonnes of uranium each year.
>
> For a nuclear weapon state considering whether to proceed with nuclear power, therefore, the choice is not between using its uranium for nuclear weapons or for nuclear power – the quantities required for nuclear power are so much larger that the actual choice is whether to generate base load electricity with uranium, or coal, or gas, or hydropower.[77]

8.80 ASTEC also examined this issue and concluded that:

> … while supply of Australian uranium could in theory release other material for weapons use, in practice this does not occur. Indeed we conclude that denial of supply to nuclear weapon states would not affect in any way their weapons programs. There is, therefore, no practical purpose to be served by refusing supply to those states. To do so would be an empty gesture and would certainly not advance the cause of disarmament.[78]

Reprocessing and plutonium stockpiles

8.81 As described in the overview of the nuclear fuel cycle in chapter two, plutonium is formed during fission in the reactor uranium fuel. Used reactor fuel can undergo reprocessing whereby the plutonium is separated out from the unused uranium and waste products. Reprocessing enables the recycling of the plutonium and unused uranium-235 into fresh fuel. The plutonium can be used for the manufacture of mixed oxide (MOX)

77 *ibid.*; and the Hon Alexander Downer MP, *Submission no. 33.1*, p. 11.

78 ASTEC, *op. cit.*, p. 95.

fuel, which is made from a mixture of plutonium and depleted uranium oxide.[79]

8.82 The FOE alleged that successive Australian Governments have contributed to global and regional proliferation risks and tensions by permitting reprocessing of used fuel containing AONM and the 'stockpiling' of Australian-obligated plutonium. It was also argued that, worldwide, reprocessing currently outstrips the use of plutonium in MOX:

> Reprocessing is difficult to justify even when the plutonium and/or recovered uranium are used as fuel. To be reprocessing well in excess of the demand for extracted plutonium or uranium is indefensible and poses a significant proliferation risk.[80]

8.83 FOE specifically argued that the separation and stockpiling of plutonium in Japan occurs in far greater quantities than can be justified by its limited use in MOX fuel. It was claimed that at the end of 2003, Japan's holdings of unirradiated plutonium amounted to 5.4 tonnes, in addition to 35.2 tonnes held overseas and 105 tonnes of plutonium in spent fuel at reactor sites and processing plants.[81]

8.84 Other evidence claimed that there is currently some 1 250 tonnes of civil plutonium world wide and another 250 tonnes of plutonium that has been produced specifically for use in weapons. The world's nuclear reactors were said to be producing an additional 70 tonnes of plutonium per year.[82]

8.85 FOE argued that it poses a proliferation risk for Japan to possess stockpiles of Australian-obligated plutonium which, given regional tensions, could be used by Japan should it decide to develop nuclear weapons.[83] It was also argued that, even in the absence of a nuclear weapons program, the very existence of plutonium in Japan exacerbates regional tensions in north-east Asia:

> Regardless of the intentions driving Japan's plutonium program, it certainly enhances Japan's capacity to produce nuclear weapons, and to do so in a short space of time. That latent potential is an ongoing source of tension in north-east Asia—it provides both an incentive and an excuse for countries such as North Korea, South Korea and Taiwan to pursue nuclear weapons programs or to steer ostensibly civil nuclear programs in such a way as to reduce the

79 UIC, *Plutonium*, Nuclear Issues Briefing Paper No. 18, viewed 20 July, <http://www.uic.com.au/nip18.htm>.

80 FOE, *Submission no. 52*, p. 17.

81 *ibid*., p. 24.

82 MAPW (Victorian Branch), *Exhibit no. 51, The Proliferation Consequences of Global Stocks of Separated Civil Plutonium*, p. 1.

83 FOE, *Submission no. 52*, p. 23.

> lead-time for weapons production (e.g. the development of reprocessing capabilities). It generates resentment when South Korea and Taiwan are prevented from pursuing similar policies to Japan.[84]

8.86 Professor Richard Broinowski also argued that exporting uranium to North and East Asian countries contributes to regional tensions:

> The Japanese nuclear industry is one of our largest customers. They have admitted that some of their plutonium has gone missing. Right now in north Asia we have a situation where if North Korea does not have nuclear weapons already they surely will. I can assure you that my professional judgment is that if they do, Japan is going to declare that it has them too, South Korea will as well, and Taiwan probably will too. This is not a joke. This is really serious; these are our most important customers for uranium.[85]

8.87 Similarly, AMP Capital Investors Sustainable Funds Team (AMP CISFT) expressed the concern that Japan is able to use Australian uranium in its fast breeder reactor, which produces plutonium, and People for Nuclear Disarmament also expressed opposition to use of fast breeder technology for this reason.[86]

8.88 FOE and the AMP CISFT called for permission for the reprocessing of spent fuel containing Australian-obligated plutonium to be withdrawn, or at least 'in circumstances of plutonium stockpiling' as is said to occur in Japan.[87] The existence of stockpiled Australian-obligated plutonium in Euratom countries was also opposed. MAPW (Victorian Branch) also argued that the non-proliferation regime would be significantly strengthened if reprocessing and the production and use of MOX were stopped.[88]

8.89 In contrast, the UIC pointed out that Japan's national policy is to use plutonium in MOX fuel and the country is currently constructing a MOX fuel fabrication plant (at Rokkasho) in which the plutonium will be used. It was also argued, as will be discussed further below, that the separated

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84 *ibid*., p. 24.

85 Professor Richard Broinowski, *Transcript of Evidence*, *op. cit.*, p. 18; Professor Richard Broinowski, *Submission no. 72*, p. 3.

86 Dr Ian Woods (AMP CISFT), *Transcript of Evidence*, 16 September 2005, p. 29; People for Nuclear Disarmament (NSW) Inc, *op. cit.*, p. 5.

87 FOE, *Submission no. 52*, pp. 16, 21; AMP CISFT, *loc. cit*.

88 MAPW (Victorian Branch), *Exhibit no. 79, op. cit.*, p. 6.

reactor grade plutonium has an isotopic composition which renders it 'totally unusable for anybody's weapons.'[89]

8.90 Use of MOX fuel was also said to have a number of important benefits, including that it will enable Japan (and other countries that recycle plutonium) to extend by about one-third the amount of energy the country obtains from the uranium they buy. Plutonium recycling offers substantially greater efficiency because energy is produced from the most abundant uranium isotope, U-238, through conversion of U-238 to plutonium and not just from the fissile isotope U-235, which constitutes only 0.7 percent of natural uranium.[90] Use of MOX fuel therefore offers Japan additional energy security by further reducing dependence on imported fuels, it conserves uranium resources, and it also reduces the amount of highly radioactive waste that must be disposed of.[91]

8.91 The UIC also argued that if Australia were to withhold uranium supplies it is likely that some countries 'will seek supplies from places that cannot boast Australia's record of influence to ensure the safety of the nuclear fuel cycle and the control of weapons proliferation.'[92]

8.92 ACF were also critical of Australia's uranium sale conditions and argued that:

> Australia does not have a credible track record on uranium sales in the nuclear trade. There is a range of obvious conditions that … should be added to those conditions of export. [93]

8.93 These additional conditions include a prohibition on the reprocessing of used fuel made from Australian uranium. That is, ACF also oppose the separation and recycling of Australian obligated plutonium. ACF also urged that customer countries should be required to have ratified the Comprehensive Test Ban Treaty (CTBT) prior to receiving Australian uranium, and that the declared NWS further their obligations to disarm under the NPT. These countries should also be required to support a 'credible' fissile material cut-off treaty (FMCT).[94]

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89 Mr Ian Hore-Lacy (UIC), *Transcript of Evidence*, 19 August 2005, p. 95.

90 Theoretically, plutonium recycling offers some 150 times as much energy from a given quantity of uranium as using uranium without reprocessing, although practical factors this level of efficiency being attained. See: UIC, *Plutonium*, *loc. cit*.

91 *ibid*.

92 *ibid*., p. 89.

93 Mr David Noonan (ACF), *Transcript of Evidence*, 19 August 2005, p. 85.

94 *ibid*., p. 76.

Weapons useability of reactor grade plutonium

8.94 Opponents of nuclear power, reprocessing and the use of MOX argued that these represent a proliferation risk because the plutonium recovered from reprocessing is said to be useable for nuclear weapons. FOE and others asserted that:

> … the overwhelming weight of expert opinion holds that reactor-grade plutonium can be used in weapons, albeit … that the process may be more dangerous and difficult.[95]

8.95 In support of this argument, it was claimed that a weapons test conducted by the US Government in 1962 used reactor-grade plutonium. It was also argued that the quantity of plutonium produced in power reactors each year 'is sufficient to produce 7,000 weapons.'[96]

8.96 According to the UIC, the plutonium content of spent fuel from the normal operation of a light water reactor (LWR), which is the most common type of nuclear reactor, will be approximately one per cent when the fuel is unloaded. At this point, the isotopic composition of the plutonium will be approximately 55 per cent Pu-239, 23 per cent Pu-240, 12 per cent Pu-241 and lesser quantities of other isotopes.[97]

8.97 The isotopic composition of plutonium is significant because it affects the material's suitability for particular purposes, such as use in a reactor or use in weapons. The plutonium isotope most suitable for weapons use is Pu-239. Weapon-grade plutonium is comprised of at least 92 per cent Pu-239 and no more than seven per cent Pu-240, while reactor-grade plutonium, produced in the normal operation of LWRs and from which MOX is made, is typically comprised of less than 60 per cent Pu-239 and greater than 18 per cent Pu-240. Fuel-grade plutonium is an intermediate category comprised of between seven to 18 per cent Pu-240.[98]

8.98 The longer that reactor fuel is irradiated (the higher the 'burn-up'), a greater quantity of higher plutonium isotopes (Pu-240, Pu-241 and Pu-242) will be formed. In normal operations, uranium fuel remains in a reactor for three to four years, which produces plutonium with a substantial proportion of these higher isotopes, as noted above (approximately 25 per cent Pu-240). Pu-240 and Pu-242 are undesirable for weapons purposes because their rate of spontaneous fission causes premature chain reactions

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95 FOE et. al., *Exhibit no. 71*, *op. cit.*, section 3.3; Mr Colin Mitchell, *Submission no. 67*, p. 1.

96 *ibid*.

97 UIC, *Plutonium*, *loc. cit*.

98 See: ASNO, 'Recycling: The Use of MOX Fuel', *Annual Report 1998-1999*, viewed 21 July 2006, <http://www.asno.dfat.gov.au/annual_report_9899/ct_plutonium.html>; GlobalSecurity.org, *Plutonium isotopes*, viewed 21 July 2006, <http://www.globalsecurity.org/wmd/intro/pu-isotope.htm>.

(pre-initiation). In addition, the radiation and heat levels would adversely effect weapon components. Consequently, ASNO observed that because of the need to minimise the Pu-240 content, weapon-grade plutonium has hitherto been produced in dedicated plutonium production reactors (usually natural uranium-fuelled and graphite moderated), specially designed and operated to produce plutonium of weapon quality by removal and reprocessing after short irradiation times.[99]

8.99 ASNO noted that while the isotopic composition of reactor-grade plutonium would create the serious technical difficulties for weapons use mentioned above, these could 'possibly be overcome, to some extent at least, by experienced weapons designers'.[100] Similarly, the UIC observed that:

> An explosive device could be made from plutonium extracted from low burn-up reactor fuel (i.e. if the fuel had only been used for a short time), but any significant proportions of Pu-240 in it would make it hazardous to the bomb makers, as well as unreliable and unpredictable.[101]

8.100 However, while it was noted that the various technical difficulties could be overcome, Mr Carlson stated that 'ASNO is not aware of any successful test explosion using reactor grade plutonium, typical of light water reactor fuel.'[102] This contradicted FOE's assertion that the 1962 weapons test was conducted using reactor grade plutonium and other evidence cited by MAPW (Victorian Branch) that claimed another such a device was exploded by the British Government in 1956.[103] As explained below, before the current plutonium grade definitions were introduced in the 1970s, there were only two terms in use to define plutonium grades: weapon-grade (no more than seven per cent Pu-240) and reactor-grade (greater than seven per cent Pu-240):

> The US conducted a test in 1962 using what they described as reactor grade plutonium. In those days, there were only two grades of plutonium, weapons grade and reactor grade. Also, plutonium did not exist in the very high burn up levels that we have today with normal power reactors. The US say they acquired this particular plutonium from the UK …
>
> At any rate, the US have refused to reveal what the isotopic composition was. There is some evidence that it contained around

99 ASNO, 'Recycling: The Use of MOX Fuel', *loc. cit*.

100 Cited in the Hon Alexander Downer MP, *Submission no. 33.1*, p. 4.

101 UIC, *Plutonium, loc. cit*.

102 Cited in the Hon Alexander Downer MP, *Submission no. 33.1*, p. 5.

103 MAPW (Victorian Branch), *Exhibit no. 51, op. cit*., p. 4.

> 10 per cent plutonium 240. Weapons grade would contain less than seven per cent plutonium 240. What is now known as reactor grade has something like 20 plus per cent plutonium 240. In the 1970s, the definitions of plutonium were changed and a new category of what was called fuel grade was introduced. Now the categories are weapons grade, which goes up to seven per cent plutonium 240, fuel grade, which goes from seven per cent to 19 per cent plutonium 240, and reactor grade, which is 19 per cent plus. What is today reactor grade did not exist in the early 1960s. There are a number of American specialists who have assured me that the 1962 test was not reactor grade as it is now defined.
>
> The antinuclear groups are trying to make too much of this issue. The reason I went into print on this in my annual report was because I was concerned at the assertions being made that Australian uranium is building up plutonium stockpiles around the world which equate to X-thousand weapons, the implication being that this is all weapons quality material which could be readily seized by the country concerned if it ever decided to pursue nuclear weapons. This is extremely misleading.
>
> … I do not believe that reactor grade plutonium has been tested as being capable of producing a nuclear explosion, but theoretically it could produce a nuclear explosion. It certainly could by a weapons state that has substantial experience—the United States, for instance, having conducted some 1,500 or 1,600 tests. If anyone could produce an explosion out of reactor grade plutonium, they could.[104]

8.101 From ASNO's explanation, it seems probable that the 1962 weapon test was conducted with what is currently defined as fuel-grade plutonium, not reactor-grade plutonium. Mr Carlson also speculated that if those countries with major nuclear power programs wanted to pursue nuclear weapons they would not do so using power reactor fuel:

> … it is pointless. They would have something of uncertain performance; they could not be sure whether it would function as intended. They would go for something that is much more certain. You can see that in the way the nuclear weapons states themselves have proceeded. If power reactor fuel is so attractive, why have those countries set up special reactors with very low burn-up fuel to produce high levels of plutonium 239? Why have they done that if they think that ordinary power reactor fuel is just as good?[105]

104 Mr John Carlson, *op. cit.*, pp. 25–26.

105 *ibid.*, p. 26.

8.102 The UIC also submitted that there are profound differences of opinion on whether reactor grade plutonium is useable for nuclear weapons:

> The facts are, first, that normal reactor-grade plutonium has about one-third non-fissile isotopes in it. The second fact is that nothing like that has ever been made to explode. The 1962 test that has been referred to was certainly of plutonium recovered from British spent fuel, from the Magnox reactors and the best intelligence I have is that that was about 15 per cent non-fissile. The third fact—and I think these facts are not disputed—is that for anybody trying to make a weapon using any plutonium, it is a very high-tech operation. It is not a terrorist backyard job. Finally, if that attempt to make a plutonium weapon were attempted with reactor-grade plutonium with a high amount of plutonium-240 in it, it would be a very hazardous and fraught undertaking. I do not think anyone disputes that. It would be almost suicidal, if not definitely suicidal, because plutonium has a high rate of spontaneous neutron emission.[106]

8.103 The UIC and ASNO emphasised that, in any case, plutonium obtained from reprocessing is treated for safeguards purposes as if it *is* weapons useable and the material is subject to strong security. Mr Carlson stated that:

> … all separated plutonium has to be subject to strong security … But that is quite a different proposition to saying that Australian uranium is generating massive quantities that are likely to be turned into nuclear weapons.[107]

8.104 In its *1998–1999 Annual Report*, ASNO insisted that while the IAEA has acted prudently in classifying all plutonium, including reactor-grade plutonium, as 'direct-use' material (that is, nuclear material that can be used for the manufacture of nuclear explosives components without further transmutation or enrichment), the IAEA is *not* thereby saying that all plutonium is suitable for weapons or that nuclear explosives can be made from spent fuel or from MOX.[108]

SILEX enrichment technology

8.105 The MAPW expressed concern about R&D activity into laser enrichment technology being developed in Australia by Silex Systems Ltd (Silex). It was argued that the features of the Separation of Isotopes by Laser

106 Mr Ian Hore-Lacy (UIC), *Transcript of Evidence*, 19 August 2005, p. 94.

107 Mr John Carlson, *op. cit.*, p. 26.

108 ASNO, 'Recycling: The Use of MOX Fuel', *loc. cit.*

Excitation (SILEX) technology that make it commercially attractive also add to its proliferation risk.[109] These commercial advantages were said to be its relatively simple and modular design, versatility in deployment and relatively low capital costs:

> Essentially what this technology would enable, if further developed, would be the enrichment of uranium on a smaller scale, much more cheaply, without the huge industrial infrastructure, high energy demand, large-scale plant facilities, high-level technical sophistication and manufacturing capacity that is required to produce traditional gas centrifugation or other enrichment plants.
>
> One could envisage that if this technology is further developed … it could make it possible for a terrorist group or government, in a space probably a quarter of the size of this room, without huge high-voltage power lines and large industrial scale, visible, detectable infrastructure, to enrich sufficient material for the production of a couple of nuclear weapons per year.
>
> For Australia to be allowing this highly proliferation sensitive research—which is the only privately held research, to public knowledge, that has the highest security classification from the US Department of Energy—to be conducted in a publicly funded facility at Lucas Heights, utilising the facility and presumably the safety waste management and other infrastructure at the plant, is entirely incompatible with Australia's non-proliferation objectives and should be closed forthwith.[110]

8.106 MAPW (Victorian Branch) also argued that:

> If the Silex process is fully developed, its eventual use for the production of fissile materials for use in nuclear weapons is probably inevitable. Thus in addition to Australian uranium exports fuelling weapons proliferation risks by contributing to the global pool of enriched uranium, successive Australian governments have allowed and supported highly proliferation sensitive enrichment R&D to be conducted in a public Australian facility, while publicly supporting non-proliferation. This is an inconsistent, immoral and indefensible position.[111]

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109 MAPW (Victorian Branch), *op. cit.*, pp. 6–9. As discussed in chapter ten, in May 2006 Silex announced that it had entered into a commercialisation and license agreement for SILEX technology with General Electric. A test loop, pilot plant and a full-scale commercial enrichment facility will be constructed in the US.

110 Associate Professor Tilman Ruff, *op. cit.*, pp. 27–28.

111 MAPW (Victorian Branch), *op. cit.*, p. 9.

8.107 The MAPW also cited a report by the Carnegie Endowment for International Peace which alleges that previous attempts at laser enrichment have been part of nuclear weapons development programs in Iran, South Korea, Brazil, Iraq and South Africa.[112]

8.108 Silex responded to these claims, arguing that laser enrichment technology is far more complex and sophisticated than gas centrifuge enrichment and that proliferators will always opt for gas centrifuge enrichment or extract plutonium from used nuclear fuel to obtain fissile material. While it was conceded that the SILEX technology is economically superior to the alternatives, it was argued that:

> … proliferators are not interested in economics; they are interested in getting the weapons material. This has been proven in the past—proliferators have not bothered with lasers; they have always gone for centrifuges.[113]

8.109 In addition, Silex argued that it is the most heavily regulated company in Australia and cited Australia's non-proliferation track record and safeguards. It was noted that a US-Australia treaty was adopted in 2000 which specifically relates to cooperation on developing SILEX technology, regulation and safeguards procedures that both Silex and any US companies interested in partnering with Silex must be subject to:

> So this is a very comprehensive process to safeguard our technology. I believe that we are the most heavily regulated company in Australia, and so we should be because we have this significant technology. We have been housed inside the secure area of Lucas Heights ever since this project started in 1990 and we have been very effectively safeguarded for 15 years … There has been a very effective process of safeguards. I can assure you that the SILEX technology is not adding to the threat or the risk of nuclear proliferation in the world today or in the future.[114]

8.110 In response to allegations that SILEX technology could conceivably be deployed in small spaces, such as a garage, and therefore be easier to conceal than existing enrichment technologies, Silex displayed confidential schematics for the Committee of a conceptual enrichment plant using the SILEX technology. It was explained that:

> It will not fit in anyone's garage … You can see the scale. This is a smallish commercial plant … and you cannot have equipment of a lesser size than this. You cannot pick up this stuff and carry it

112 MAPW (Victorian Branch), *Submission no. 30.1*, pp. 18–20.

113 Dr Michael Goldsworthy (Silex Systems Ltd), *Transcript of Evidence*, 9 February 2006, pp. 5, 13.

114 *ibid.*, p. 5.

> away. It is still very big machinery. The difference between this and centrifuge and diffusion is that diffusion and centrifuge would have 100 of these, not just one. So it is still a very big plant but it is not, as the critics make out, portable.[115]

8.111 ASNO agreed that enrichment technology and facilities must be very carefully regulated because, as noted above, it is one of the routes to producing fissile material. However, ASNO also argued that Silex's technology does not represent a substantial proliferation danger.[116]

8.112 Mr John Carlson stated that ASNO is actually pleased that Silex is renting premises at Lucas Heights because of the strong security at the site. The SILEX technology has also been designated under the Safeguards Act so that access to the technology is limited to named individuals who have been personally authorised after undergoing security vetting. In relation to its dealings with American companies, as noted above, the Australian and US Governments established a so-called Silex agreement which came into effect in 2000 which allows for technology transfer between the two countries. The US Government have likewise classified the technology as 'restricted data'.

8.113 As to the proliferation sensitivity of the SILEX technology, ASNO disputed claims that the technology could produce very high enrichment levels: 'The company has not sought to find out. We would not authorise it.'[117]

8.114 ASNO also disputed arguments that the technology could be hidden in a 'garage' and produce quantities of fissile material for a weapon. It was also argued that the components required for the SILEX process are extremely complex and therefore not a technology that proliferators would choose:

> The Silex equipment is in fact quite bulky. You can build a small laser application—as you know, lasers are used in all sorts of things. Even for demonstrating isotopic separation it would be possible to build something on a relatively small scale that could separate nanograms. But if you want something that can produce kilogram quantities, for a nuclear weapon you would need a minimum of 15 kilograms of uranium-235. If you want something that can have a throughput and that will give you that level of production, you would need to go into equipment which is much larger and have a plant which is a lot larger. Our assessment is

115 *ibid.*, p. 14.

116 Mr John Carlson, *op. cit.*, p. 25.

117 Mr John Carlson, *op. cit.*, p. 24.

> that if you are looking at a plant—if we look at the Iraqi and Libyan experience we could say that the minimum plant size to produce enough high-enriched uranium for one nuclear weapon in a year would need a plant which has an output of around 10,000 SWU [separative work units] a year, around 2,000 centrifuges.
>
> If we assume that someone is attempting to build a Silex project that would give that kind of throughput, our assessment is that the plant would be larger than a centrifuge plant in fact and would need a small industrial building. It is not something that could be readily hidden. On top of that, the Silex process requires extremely complicated components which are very difficult to manufacture. There are only a handful of countries that are even capable of producing the various components that would be required. It is not really something that a proliferator would pursue. We would regard it as being an extremely difficult route to go down. Our concern is with centrifuge enrichment because the technology is easier, and unfortunately it is now out and about in the marketplace. We do not believe that the Silex process represents a substantial danger.[118]

8.115 ASNO informed the Committee that the main proliferation risk is with centrifuge enrichment technology, which is relatively compact and requires less electricity that older enrichment technology. While centrifuge enrichment is technically complex, the:

> … know-how for designing and operating centrifuges has gradually spread, particularly through the efforts of Pakistani nuclear expert Abdul Qadeer (A Q) Khan, who stole Dutch technology.[119]

8.116 ASNO noted that A Q Khan was responsible for selling stolen centrifuge technology to Iran, Libya and North Korea. There have also been individuals of German, Swiss and British backgrounds, who were involved in the Urenco centrifuge program, who sold technology to aid the Iraqi program.

Uranium exports to China

8.117 As noted above, in April 2006 Australia and China entered into a bilateral safeguards agreement on the transfer of nuclear material, whereby sales of uranium to China will now be permitted.[120] Australian uranium cannot be

118 *ibid.*, pp. 24–25.

119 Mr John Carlson, *op. cit.*, p. 21.

120 ASNO, *Agreement Between the Government of Australia and The Government of the People's Republic of China on the Transfer of Nuclear Material, loc. cit.*

transferred to China until the agreement is in force and administrative arrangements have been concluded between ASNO and the China Atomic Energy Authority.[121]

8.118 The Committee received evidence from FOE and others opposing the sale of uranium to China on the basis of the following claims:

- the IAEA inspections program is 'under resourced' and thus it is 'highly unlikely' that inspections would be sufficiently numerous or rigorous to detect any diversions of AONM;
- Australia's bilateral safeguards agreements are 'meaningless' and have been 'repeatedly weakened' since the framework was established in 1977;
- China maintains an active weapons program and refuses to ratify the CTBT;
- the Chinese regime has a record of military exports;
- Australian uranium could be used in weapons if regional tensions over Taiwan escalate into war;
- Australia's uranium exports will allow China to use more of its indigenous supplies for its weapons programs;
- China does not have civil society safeguards such as whistleblower protection and there are 'examples of persecution of nuclear whistleblowers';
- the Chinese regime tightly controls the media and if diversions were to occur it is 'highly unlikely that the media would be unable to uncover and report on the diversion';
- uranium sales to China would allegedly set a 'poor precedent' for sales to 'repressive, secretive, military states'; and
- China lacks plans for public safety in case of an emergency or for managing spent fuel.[122]

8.119 ACF also opposed sales of uranium to China on the basis that it is not an 'open society' and therefore allegedly cannot be trusted:

> That China is not an open society predicates against reliance on state assurances over proliferation and management of AONM. Apparently the China export arrangements are proposed to allow enrichment of Australian uranium in China. This would further compromise any claimed control over AONM within China.[123]

121 ASNO, Australia-China Nuclear Material Transfer Agreement and Nuclear Cooperation Agreement, *Frequently Asked Questions*, *loc. cit.*

122 FOE, *Submission no.52.4*, pp. 4–6. See also: Mr Colin Mitchell, *Submission no. 67*, p. 1.

123 ACF, *Submission no.* 48, p. 12.

8.120 Exports were also opposed because China was said to be a nuclear weapon state still developing weapons programs, and that supplying uranium to China would in effect be:

> … freeing them up to use their own limited uranium supplies in their nuclear weapons programs. An indirect Australian facilitation of these programs.[124]

8.121 Responses to several of these allegations were presented in the evidence cited in preceding sections and in the previous chapter, notably the claims that: Australia's uranium will simply displace Chinese uranium for use in its weapons programs; resource constraints limit IAEA's inspections; alleged weakening of Australia's bilateral safeguards; and the production of fissile material for weapons programs.[125]

8.122 In its *2004–2005 Annual Report*, ASNO reiterated that the assurance that AONM will not be used in nuclear weapons in China comes from a combination of factors: China's willingness to undertake a legally-binding treaty-level commitment to this effect; the safeguards arrangements that will apply; and the factual circumstances as outlined below.

8.123 These circumstances include that Australia's uranium will be bought by Chinese power utilities for electricity generation. The Nuclear Material Transfer Agreement ensures that AONM will be used or processed only within a jointly agreed list of facilities, which will be subject to China's safeguards agreement with the IAEA. While China has the right to choose which facilities are eligible for IAEA inspections, Australia and China must jointly agree on which facilities will be eligible to use AONM under the Agreement. AONM is not eligible for use in military facilities. Monitoring of AONM in China will be based on safeguards procedures applied at facilities where AONM is handled in accordance with China's safeguards agreement with the IAEA and the Administrative Arrangements concluded with Australia. ASNO explained that it will cross check reports on AONM provided by China for consistency with information from the IAEA and other sources.[126]

8.124 ASNO repeated its belief that China has no reason to divert civil material for its military program. In the first place, the quantities of uranium required for nuclear power are so much larger than that required for weapons and, second, while China has not stated officially that it has

124 *ibid*. See also: Mr David Noonan (ACF), *Transcript of Evidence*, 19 August 2005, p. 76.

125 See also: The Hon Alexander Downer MP, *Submission no. 33.3*, pp. 1–2.

126 ASNO, *Annual Report 2004–2005, op. cit.*, p. 18. See also: ASNO, Australia-China Nuclear Material Transfer Agreement and Nuclear Cooperation Agreement, *Frequently Asked Questions, loc. cit.*

ceased production of fissile material for weapons, unofficial statements indicate such production ended in 1991.[127]

The US-India Nuclear Agreement and possible exports of Australian uranium

8.125 As a non-NPT Party, India has hitherto not been eligible for nuclear cooperation under current internationally established export control arrangements, particularly those guidelines established by the Nuclear Suppliers Group (NSG). However, on 18 July 2005 the US President and the Indian Prime Minister issued a joint statement announcing a civil nuclear energy cooperation agreement.[128] Under the agreement, the US undertook to:

- seek agreement from Congress to adjust US laws and policies to achieve full civil nuclear energy cooperation;
- work with allies to adjust international regimes to enable full civil nuclear energy cooperation and trade with India, including early consideration of fuel supplies for safeguarded nuclear reactors (at Tarapur);
- in the meantime, encourage its partners to consider fuel supply (to Tarapur) expeditiously;
- consult with its partners to consider India's participation in the International Thermonuclear Experimental Reactor (ITER) project; and
- consult with other participants in the Generation-IV International Forum with a view towards India's inclusion.[129]

8.126 For its part, India undertook to:

- identify and separate civil and military nuclear facilities and programs in a phased manner;
- file a declaration regarding its civil nuclear facilities with the IAEA;
- voluntarily place its civil nuclear facilities under IAEA safeguards 'in perpetuity';
- sign and adhere to an Additional Protocol with the IAEA with respect to civil facilities;

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127 *ibid.*, pp. 18–19.

128 Joint Statement Between President George W. Bush and Prime Minister Manmohan Singh, 18 July 2005, , viewed 28 July 2006, <http://www.whitehouse.gov/news/releases/2005/07/20050718-6.html>.

129 *ibid.*

- harmonise its export controls with the NSG and Missile Technology Control Regime (MTCR) Guidelines, although India is not a member of either group;
- upgrade its non-proliferation regulations and export controls (which has taken place in part as a result of a *Weapons of Mass Destruction Act* of May 2005);
- refrain from transfer of enrichment and reprocessing technologies to states that do not have them, and to support international efforts to limit the spread of these technologies;
- continue a unilateral moratorium on nuclear testing; and
- work with the US for the conclusion of a multilateral FMCT.[130]

8.127 ASNO explained that under the agreement, the US has committed to broaden the level of co-operation that is possible, including for the supply of nuclear fuel to safeguarded reactors, and will seek to persuade other members of the international community to adopt that policy.[131] In particular, the US will seek to have the NSG adjust its practices so that India can obtain full access to the international nuclear fuel market, including 'reliable, uninterrupted and continual access to fuel supplies from firms in several nations.'[132]

8.128 India currently has 22 thermal reactors in operation or currently under construction. Under its nuclear separation plan, which was announced in March 2006, India has committed to place 14 of its thermal reactors under IAEA safeguards between 2006 and 2014 (including four reactors that are already under safeguards). India will also place under safeguards all future civil reactors, both thermal and breeder reactors.[133]

8.129 Steps necessary for the implementation of the agreement include: amendment of US legislation to allow the nuclear supply to India; conclusion of a nuclear cooperation agreement between the US and India; conclusion of a safeguards agreement and Additional Protocol between India and the IAEA; and agreement within the NSG, either to make an exception to its conditions to allow nuclear supply to India, or to change its conditions (which ASNO believes is unlikely). ASNO noted that as of 1 June 2006, negotiations and consultations had commenced on each of these steps. On 26 July 2006, the US House of Representatives voted, by a

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130 *ibid*. ASNO, *Exhibit no. 92, Informal brief on US-India Nuclear Agreement*, pp. 1–2.

131 Mr John Carlson, *op. cit.*, p. 18.

132 ASNO, *Exhibit no. 92, op. cit.*, p. 2.

133 *ibid*., pp. 5–6.

large majority, to approve amendments to relevant US laws to give effect to the agreement.[134]

8.130 The US Government has argued that the agreement will have important non-proliferation benefits:

> … this initiative brings India into the global nuclear non-proliferation mainstream. For the first time, India has committed to take the significant steps described above that will end its 30 year isolation from the global regime and will increase the transparency of its civilian nuclear program, improve the safety and the effectiveness of that program, and provide oversight—again for the first time—over a large majority of Indian civilian nuclear reactors and the associated upstream and downstream facilities that support those reactors.[135]

8.131 Several countries have expressed support for the agreement, including Russia, France, Japan and the UK. The Director General of the IAEA also welcomed the agreement, noting India's intention to identify and place all its civilian nuclear facilities under IAEA safeguards and sign and adhere to an Additional Protocol with respect to its civilian nuclear facilities:

> This agreement is an important step towards satisfying India's growing need for energy, including nuclear technology and fuel, as an engine for development. It would also bring India closer as an important partner in the non-proliferation regime … It would be a milestone, timely for ongoing efforts to consolidate the non-proliferation regime, combat nuclear terrorism and strengthen nuclear safety.
>
> The agreement would assure India of reliable access to nuclear technology and nuclear fuel. It would also be a step forward towards universalisation of the international safeguards regime … This agreement would serve the interests of both India and the international community.[136]

8.132 The Australian Government has also welcomed the agreement as a very positive development, noting that it has paved the way for the expanded application of IAEA safeguards which will allow the IAEA enhanced access rights in India. The Government also noted that the agreement

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134 *ibid*., p. 4.

135 US Department of State, Bureau of Public Affairs, *U.S.- India Civil Nuclear Cooperation Initiative*, Fact Sheet, issued 9 March 2006, viewed 28 July 2006, <http://www.state.gov/documents/organization/63007.pdf>.

136 Dr Mohamed ElBaradei, *IAEA Director General Welcomes U.S. and India Nuclear Deal*, Press Releases, 2 March 2006, viewed 28 July 2006, <http://www.iaea.org/NewsCenter/PressReleases/2006/prn200605.html>.

would help meet India's economic development and energy needs in an environmentally clean manner. However, ASNO indicated that the Australian Government would like to see India ratify the CTBT and to cease production of fissile material for nuclear weapons immediately.[137]

8.133 It was noted in chapter two that India is currently constructing eight reactors and intends to triple nuclear generating capacity to 20 gigawatts electrical by 2020. India also plans that by 2050 nuclear power will contribute 25 per cent of the country's electricity generation—a hundredfold increase on 2002 nuclear generating capacity.[138] ASNO observed that 'it is essential that this program is based on high safety standards—but this would not be helped by continued denial of modern technology and cooperation.'[139] It was also observed that if India's electricity demand, which is predicted to increase by as much as ten-fold by 2050, is met instead by fossil fuels then 'there would be significant environmental and greenhouse emission consequences.'[140]

8.134 In October 2005 ASNO informed the Committee that the Australian Government's policy, which excludes the possibility of uranium supply to India because it is not an NPT party, was not under review and that the Indian Government had not asked Australia to supply uranium.[141] However, such a request was made to the Prime Minister during his visit to India in March 2006. It was subsequently announced that the Australian Government would send a delegation to India and the US to study the civil nuclear energy cooperation agreement.

8.135 ASNO observed that while the Indian Government has consistently supported the objective of non-proliferation and nuclear disarmament, it regards the NPT as discriminatory:

> … because the non-proliferation treaty recognises the five nuclear weapons states that existed at the time the treaty was concluded and makes no provision for any further nuclear weapons states. India felt that this was discriminatory—that the treaty should apply equally to every state—and has refused to join …[142]

8.136 An important issue is that, currently, the NSG—countries that export nuclear material and technology, which includes Australia—have adopted the full scope safeguard standard; that is, suppliers will not supply to

137 ASNO, *Annual Report 2004–2005, op. cit.*, p. 17; Mr John Carlson, *loc. cit.*

138 UIC, *Nuclear Power in India and Pakistan*, Nuclear Issues Briefing Paper No. 45, viewed 1 June 2006, <http://www.uic.com.au/nip45.htm>.

139 ASNO, *Annual Report 2004–2005, loc. cit.*

140 *ibid.*

141 Mr John Carlson, *loc. cit.*

142 *ibid.*, p. 17.

NNWS that do not accept full scope safeguards, which are IAEA safeguards on *all* existing and future nuclear activities. The majority of the Indian nuclear program is currently outside of safeguards and the nuclear suppliers' guidelines do not currently permit nuclear cooperation with India, except in the area of nuclear safety. This has effectively meant that India is isolated from world nuclear trade. The NSG is unlikely to decide whether it will grant an exception to its guidelines until the relevant legislation has passed through the US Congress, although the US Administration anticipates a favourable decision from the NSG.[143]

8.137 During the Committee's public hearings the uranium industry in Australia had not formed a position in relation to the question of uranium supply to India, but reiterated its support for the Government's current exports policy. When specifically asked by the Committee, the UIC doubted whether the industry would want to see a change in policy:

> … all of our main members would want to go along with Australian government policy in this regard and would see that as rather important, with the two requirements [NPT membership and a bilateral agreement] … and also the third about the additional safeguard; the additional protocol.[144]

8.138 The MCA supported current policy that customer countries must be parties to the NPT, as did the Australian Nuclear Association (ANA).[145]

8.139 The World Nuclear Association's position is that there is some injustice in the current restriction on exports to India, because 'India has been very scrupulous in its non-proliferation intentions and practices.'[146] In addition, and similar to China, India's weapons program preceded its civil program, although the two are now mixed together to a greater extent than in China. China is a recognised weapons state because it conducted its first nuclear explosion in 1967, prior to the NPT coming into force in 1970, while India's first explosion was conducted in 1974 'so it was left out in the cold.'[147]

8.140 In contrast, the ACF argued that India is a 'rogue nuclear weapon state outside of international conventions' and is still developing nuclear weapons.[148] FOE argued that:

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143 ASNO, *Exhibit no. 92, op. cit.*, p. 4.

144 Mr Ian Hore-Lacy, *op. cit.*, p. 90.

145 Mr Mitch Hooke (MCA), *Transcript of Evidence*, 5 September 2005, p. 31; Dr Clarence Hardy (ANA), *op. cit.*, p. 55.

146 Mr Ian Hore-Lacy, *op. cit.*, p. 90.

147 *ibid.*, p. 91.

148 ACF, *op. cit.*, p. 11.

> Allowing nuclear co-operation and uranium sales to India would clearly weaken the NPT. Potential nuclear weapons states - in northeast Asia or the Middle East, for example - would be all the more likely to 'go nuclear' if civil nuclear co-operation and trade with non-NPT states were to become the norm.[149]

8.141 On this issue, ASNO has questioned whether adherence to the full scope safeguard can be effective in drawing those states outside the NPT into the Treaty, but emphasised that the agreement with India should not encourage states within the NPT to withdraw in the mistaken belief that they would receive similar treatment:

> Now that only three states—India, Israel and Pakistan—remain outside the NPT, and given that none of these appears likely to change its position on joining the NPT in the foreseeable future, it might be asked whether the full scope safeguards requirement can be effective in drawing these three into the Treaty. In treating India as a special case, however, it is essential that states within the NPT should not be encouraged to withdraw in the belief that a relaxation of the full scope safeguards standard for India would also be available to them. It has to be clearly established that the case of a state that has remained outside the NPT from the beginning, but otherwise supports non-proliferation principles, would be treated very differently from that of a state that has accepted the NPT's commitments and subsequently seeks to renounce them.[150]

Nuclear terrorism — nuclear weapons, 'dirty bombs' and security measures

8.142 The IAEA has identified four potential nuclear security risks: the theft of a nuclear weapon; the acquisition of nuclear materials for the construction of nuclear explosive devices; the malicious use of radioactive sources including in so-called 'dirty bombs'; and the radiological hazards caused by an attack on, or sabotage of, a facility or a transport vehicle.[151]

8.143 The fourth of these risks was addressed in chapter six. The Committee received some evidence in relation to the risk of terrorist groups acquiring nuclear materials for the construction of nuclear weapons and the potential for AONM and other radioactive material to be diverted for use

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149 FOE, *Submission no. 52.1*, p. 5.

150 ASNO, *Annual Report 2004–2005, loc. cit.*

151 Dr Mohamed ElBaradei, *Nuclear Terrorism: Identifying and Combating the Risks*, Statement of the Director General, IAEA, Vienna, 16 March 2005, viewed 14 July 2006, <http://www.iaea.org/NewsCenter/Statements/2005/ebsp2005n003.html>.

in 'dirty bombs'. Information on Australian and international activities to prevent terrorist attacks was also provided.

8.144 The MAPW (Victorian Branch) argued that if nuclear power were expanded on a significant scale, for example to displace carbon based energy sources, this would inevitably increase:

> … the volume of material, the number of facilities and the amount of material that is in transit, where it is much more susceptible to being hijacked, sabotaged or stolen than a much smaller program.[152]

8.145 The MAPW were convinced of the inevitability of a terrorist attack on a nuclear facility and argued that an expansion in exports of uranium would increase the risk:

> The risk of nuclear terrorism via a dirty bomb, a primitive nuclear explosion—one or more—or attacks on nuclear facilities is inevitable. There is really no question, to us, about that. They are an extremely attractive terrorist target. Again, increasing the range of possibilities, the number of facilities, the volume of materials, the number of places in which it is dispersed, increases the potential for that risk. Any such risk clearly can be catastrophic in a major urban area—particularly if a multiplicity of events simultaneously timed were planned—but also it could be very difficult to interpret, particularly for nuclear weapon states that have a high proportion of their weapons on hair-trigger alert … For us, these two risks alone really make this technology far more trouble and risk than it is worth.[153]

8.146 It was submitted that some terrorist groups have been trying to obtain nuclear materials, primarily from the stockpiles of the former Soviet Union, and that the international community urgently needs to expand its efforts to secure existing stockpiles of nuclear weapons and materials.[154] MAPW cited evidence which claims that plutonium from civil nuclear programs is becoming more available worldwide and that it is becoming 'increasingly possible for a terrorist group to steal, or otherwise illegally acquire, civil plutonium that could be used to fabricate a nuclear explosive device.'[155] Moreover, this evidence claimed that terrorists would be able to design and fabricate a 'relatively unsophisticated device' with some ease:

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152 Associate Professor Tilman Ruff (MAPW–Victorian Branch), *Transcript of Evidence*, 19 August 2005, p. 32.

153 *ibid.*, p. 25.

154 MAPW (Victorian Branch), *Exhibit no. 53, Nuclear terrorism*, p. 1.

155 MAPW (Victorian Branch), *Exhibit no. 55, Dirty Bombs and Primitive Nuclear Weapons*, pp. 2, 7.

> … if it acquired enough MOX fuel by diversion or theft, a sophisticated terrorist group would have little difficulty in making a crude nuclear explosive. The necessary steps of separating the plutonium from the uranium in MOX, converting it into plutonium dioxide, converting the dioxide into plutonium metal, and assembling the metal or plutonium dioxide … to fabricate a primitive nuclear weapon are not technically demanding and do not require materials form specialist suppliers.[156]

8.147 FOE argued that smuggling of nuclear materials presents a significant challenge and that the IAEA's Illicit Trafficking Database records over 650 confirmed incidents of trafficking in nuclear or other radioactive materials since 1993, at least 17 of which involved small quantities of fissile material. It was argued that: 'Smuggling can potentially provide fissile material for nuclear weapons or a wider range of radioactive materials for potential use in "dirty bombs".'[157]

8.148 In outlining the IAEA's nuclear security plan of activities to combat the four security risks listed above, the Director General of the IAEA, Dr Mohamed ElBaradei, has commented that:

> While the majority of trafficking incidents do not involve nuclear material, and while most of the radioactive materials involved are of limited radiological concern, the number of incidents shows that the measures to control and secure nuclear and other radioactive materials need to be improved.[158]

8.149 ASNO explained that the requirements to construct a nuclear weapon are a sufficient quantity of fissile material of suitable quality and very substantial technical capability. As mentioned in the previous chapter, the fissile material required to construct a nuclear weapon would need to be either very highly enriched uranium (HEU) or plutonium—HEU would need to be enriched to 70 per cent or more U-235, with weapons grade uranium normally enriched to more than 90 per cent U-235, and separated plutonium, with weapons grade plutonium being at least 93 per cent of the isotope Pu-239.[159]

8.150 While constructing a uranium-based weapon could, in principle, be relatively simple, ASNO argued that constructing a plutonium weapon is difficult. However, a uranium-based weapon would also be very bulky, therefore not deliverable by missile, and require a large amount of uranium which would also impede illicit development of such a weapon.

156 *ibid.*, pp. 8, 12.
157 FOE, *Submission no. 52*, p. 16.
158 Dr Mohamed ElBaradei, *Nuclear Terrorism: Identifying and Combating the Risks*, *loc. cit.*
159 ASNO, *Annual Report 2003–2004*, *op. cit.*, p. 107.

On the other hand, a plutonium-based weapon involves complex technology:

> … a country or a group that want to pursue nuclear weapons not only have to do a substantial amount of research in weapon design because it is not simple but also have to have a way of acquiring fissile material of the right quality. Essentially that means, if they are not able to steal it, that they would need to have enrichment or suitable reactors. The conventional light-water reactor is not a good plutonium producer for weapons and they would need to have a reprocessing plant. If they are parties to the non-proliferation treaty, they would need to be able to run these activities while evading detection by IAEA safeguards, which is a challenge. It is a challenge for IAEA safeguards to find undeclared activities, but it is also a substantial challenge for countries to hide activities.[160]

8.151 Mr Keith Alder, a former Commissioner and General Manager of the Australian Atomic Energy Commission who worked on the British nuclear weapons program, concurred with ASNO and disputed MAPW's assertion that fabricating a plutonium weapon would be straightforward. Mr Alder argued emphatically that it would be virtually impossible for a terrorist group to manufacture a nuclear weapon from the plutonium produced in civil reactors:

> The Americans, very unwisely at one stage of the game … did actually make an explosion with civil plutonium. It is very difficult, but they did it, and I think it was a stupid thing to do because it made people feel that if a terrorist got hold of that stuff he could do that. Don't you believe it. The enormous sophistication that goes into a bomb is far beyond the capability of a terrorist organisation … the sophistication of that device is not just the nuclear side but how to implode it, to make it hold together to burn for long enough to make a significant bang. To try and do that with commercial plutonium, without all the resources, all the instrumentation and so on of a major national laboratory—the mind boggles. How could that happen? The idea of a terrorist snooping in with a suitcase with a bomb he has made in his cellar is crazy.[161]

8.152 ASNO explained that terrorist groups have indeed shown interest in obtaining fissile material for nuclear weapons, but the biggest barrier for such groups is obtaining a sufficient quantity of material:

160 Mr John Carlson, *op. cit*., p. 20.

161 Mr Keith Alder, *Transcript of Evidence*, 16 September 2005, p. 86.

> Our assessment is that it would be beyond the resources of a subnational group to set up an enrichment plant or reactors and a reprocessing plant, or they could be detected. The fairly persistent worry has always been whether it would be possible for them to get hold of existing fissile material. The example that is usually brought out is from the former Soviet Union where, at the time when the Soviet Union collapsed, the controls over fissile material were fairly rudimentary. Basically, the Russian system relied on security over nuclear material—having nuclear material in remote areas with guards—without the development of an effective accounting system.[162]

8.153 ASNO stated that there has now been a substantial program to upgrade Russian capacities in relation to control of fissile material but, in any case:

> … the known cases of trafficking in nuclear materials have never shown that substantial amounts of material are leaving Russia, and certainly nothing remotely like the quantities required for a weapon.[163]

8.154 Furthermore, evidence cited by MAPW itself, which was published in 2002, stated that the US Government was then spending approximately US$900 million annually to secure weapons grade nuclear materials in Russia.[164]

8.155 ASNO explained that dirty bombs are distinguished from nuclear weapons in that the latter derive their explosive force from a nuclear chain reaction, while dirty bombs use conventional explosives to disperse radioactive material (not necessarily nuclear material—uranium, thorium or plutonium). These bombs are also known as radiological dispersal devices (RDD). The objective of a dirty bomb is contamination rather than destruction by explosive force.[165]

8.156 MAPW submitted that:

> There are literally millions of radioactive sources used worldwide in medicine, industry and agriculture; many of them could be used to fabricate a dirty bomb. They are often not kept securely. Terrorists should be able to acquire radioactive material.
>
> Deaths and injuries caused by the blast effects of the conventional explosives and long-term cancers from radiation exposure would

162 *ibid*., p. 20

163 *ibid*.

164 MAPW (Victorian Branch), *Exhibit no. 53, op. cit*., p. 2.

165 Mr John Carlson, *op. cit*., p. 18. Further information on RDDs available from the US Nuclear Regulatory Commission, *Backgrounder on Dirty Bombs*, viewed 26 July 2006, <http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/dirty-bombs-bg.html>.

> likely be minimal. The true impact of a dirty bomb would be the enormous social, psychological and economic disruption caused by radioactive contamination.[166]

8.157 ASNO and the UIC argued that in light of the IAEA and bilateral safeguards discussed above, 'the probability of AONM being used in a dirty bomb is miniscule.'[167] In particular, ASNO stressed that Australia's conditions for supply of AONM include an assurance that internationally agreed standards of physical security will be applied to nuclear material in the country concerned.

8.158 Under the *Convention on the Physical Protection of Nuclear Materials (1979)* (CPPNM), the IAEA has issued detailed guidance on the physical protection of nuclear materials and nuclear facilities. This guidance aims 'To establish conditions which would minimize the possibilities for unauthorised removal of nuclear material and/or for sabotage.'[168] ASNO explained that Australia applies these requirements domestically and, through its bilateral safeguards agreements, requires customer countries to do the same. It was argued that the requirements adequately address the possible diversion of AONM to dirty bombs.

8.159 ASNO noted in a supplementary submission that in July 2005 major amendments to the CPPNM were agreed that will strengthen the Convention and these amendments are now with governments for ratification. Whereas the original CPPNM applied only to nuclear material in international transport:

> The amended CPPNM makes it legally binding for States Parties to protect nuclear facilities and material in peaceful domestic use, storage as well as transport. It will also provide for expanded cooperation between and among States regarding rapid measures to locate and recover stolen or smuggled nuclear material, mitigate any radiological consequences of sabotage, and prevent and combat related offences.[169]

8.160 In 2003 the IAEA General Conference also endorsed a revised Code of Conduct on the Safety and Security of Radioactive Sources, which is now

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166 MAPW (Victorian Branch), *Exhibit no. 55, op. cit.*, p. 1. MAPW cited several radioisotopes that would be suitable for the purpose of fabricating a dirty bomb.

167 UIC, *op. cit.*, p. 35.

168 Cited in the Hon Alexander Downer MP, *Submission no. 33*, p. 9. In addition, with IAEA support, Russia, the US and other countries and now taking steps to convert their research reactors from HEU to LEU fuel and to return the HEU to the country of origin. The IAEA comments that these and other projects are helping to reduce the risks posed by existing nuclear material.

169 IAEA, *States Agree on Stronger Physical Protection Regime*, Press Release, 8 July 2005, viewed 26 July 2006, <http://www.iaea.org/NewsCenter/PressReleases/2005/prn200503.html>.

with governments for implementation.[170] ASNO noted that Australia has been at the forefront of efforts to strengthen the CPPNM and to develop the Code of Conduct. The Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) is coordinating Australia's implementation of the Code of Conduct.[171]

8.161 The Australian Nuclear Science and Technology Organisation (ANSTO) also submitted that the IAEA has made significant progress in developing detailed standards for the regulation of radioactive sources, including security standards. ANSTO noted that development of the Code of Conduct and supplementary Guidance on the Import and Export of Radioactive Sources took place under its chairmanship. It was argued that: 'Implementation of these standards should significantly reduce the risk of employment of highly active radioactive sources in such devices.'[172]

8.162 ANSTO also submitted that it is playing a significant regional role in this regard by initiating a project on the security of radioactive sources. The project intends to:

- improve and maintain the security of radioactive sources in regional countries, (and concomitantly, to improve and maintain the associated occupational and public radiation safety, and environmental protection);
- identify and secure uncontrolled or poorly controlled radioactive sources in regional countries; and
- reduce the security threat to regional countries potentially arising from malevolent use of radioactive sources.[173]

8.163 In his book, *Fact or Fission*, Professor Richard Broinowski argued that before the events of 11 September 2001, Australian officials could not accurately quantify how much radioactive material (such as discarded caesium, strontium, cobalt and americium used to treat patients, monitor oil wells and so on) was missing in Australia.[174]

8.164 When questioned on the management of radioactive sources in Australia and particularly on the location of so-called 'orphan' sources, which are

170 See: IAEA, *Code of Conduct on the Safety and Security of Radioactive Sources*, IAEA, Vienna, 2004, viewed 26 July 2006, <http://www-pub.iaea.org/MTCD/publications/PDF/Code-2004_web.pdf>. Further information on the IAEA's activities to control radioactive sources is available in the IAEA *Annual Report 2004*, IAEA, Vienna, 2005, pp. 49–50, viewed 27 July 2006, <http://www.iaea.org/Publications/Reports/Anrep2004/radiation_safety.pdf>.

171 The Hon Alexander Downer MP, *Submission no. 33.2*, p. 9.

172 ANSTO, *Submission no. 29*, p. 20.

173 *ibid*.

174 Professor Richard Broinowski, *Fact or Fission*, *op. cit.*, p. 276.

radioactive sources outside regulatory control, the Chief Executive Officer of ARPANSA, Dr John Loy, responded that:

> All the states have good regulatory systems and good knowledge of the location of the sources in their states, as does ARPANSA for the Commonwealth. I would not ever say that it is perfect. Certainly, as part of our current review of security issues, we are looking at how we might pursue a systematic way of looking for what is called in the trade 'orphan sources' that have come out of control in some way. My gut feeling, and I think it is shared by the state regulators, is that it is not a big problem, but that is not to say that it does not exist and that it should not be given attention.[175]

8.165 In relation to the potential for natural uranium to be used in a dirty bomb in Australia, ARPANSA and ANSTO argued that because of the low levels of radioactivity in uranium oxide, use of natural uranium would not present any hazard to human health:

> … it is considered that the use of natural uranium, such as is processed and transported by the uranium mining industry, would not present any hazard to persons or the environment if used by terrorists with malicious intent.[176]

8.166 The UIC emphasised that while dirty bombs are a distinct possibility, it is highly unlikely that terrorists would attempt to construct these from nuclear material:

> … the possibility of them doing [so] with spent nuclear fuel from the civil nuclear cycle or even a research reactor is infinitesimally small because that fuel is self-protecting by virtue of its high radioactivity … even if you were suicidal, I do not think you would do very much with it. I have not seen any suggested scenario from anybody knowledgeable that this is likely.[177]

8.167 Mr Ian Hore-Lacy, General Manager of the UIC, speculated that if dirty bombs were to be used, they are far more likely to be constructed from radioactive medical waste which can be shielded and manipulated, then blown apart, rather than from nuclear material.

8.168 MAPW conceded that: 'Spent nuclear-power reactor fuel elements are so radioactive that they are self-protecting. Any human that went near them would die very quickly.'[178] However, MAPW again called for an end to reprocessing and the use of MOX fuel, arguing that separated plutonium

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175 Dr John Loy (ARPANSA), *Transcript of Evidence*, 16 September 2005, p. 73.

176 ARPANSA, *Submission no. 32*, p. 11; ANSTO, *loc. cit.*

177 Mr Ian Hore-Lacy, *op. cit.*, p. 94.

178 MAPW (Victorian Branch), *Exhibit no. 55, op. cit.*, p. 12.

would be easier for terrorists to handle and to use in fabricating either a dirty bomb or a primitive nuclear explosive: 'The safest thing is, therefore, to leave permanently the plutonium in spent reactor fuel elements.'[179]

8.169 In relation to nuclear terrorism more generally, ASNO drew the Committee's attention to the nuclear security activities of the IAEA, as described in its annual reports.[180]

8.170 The IAEA's nuclear security plan is founded on measures to guard against thefts of nuclear and other radioactive material, and to protect related facilities against malicious acts. IAEA activities directed at enhancing nuclear security and protection against nuclear terrorism have three main points of focus: prevention, detection and response. Preventative measures are said to require: effective physical protection of nuclear or other radioactive materials in use, storage and transport; protection of related nuclear facilities; and strong state systems of accounting for and control of nuclear material. The IAEA assists states in implementing these preventative measures through activities such as International Nuclear Security Advisory Service missions (INSServ) to member states, training workshops and technical guidance documents.[181]

8.171 Among its various activities, ASNO highlighted an IAEA program to:

> … increase countries' awareness and ability to control and protect nuclear and other radioactive materials, nuclear installations and transport systems, from terrorist and other illegal activities; and to detect and respond to such events.[182]

8.172 Within this program the IAEA provides monitoring equipment, security and safety upgrades including major structural changes at nuclear facilities. Through the program, the IAEA provides International Physical Protection Assessment Service (IPPAS) missions to assess and assist Member States with physical protection systems related to nuclear material. Australia provides experts to assist in this program.[183]

8.173 In a speech on *Nuclear Terrorism: Identifying and Combating the Risks,* given in March 2005, Dr ElBaradei noted that:

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179 *ibid*.

180 IAEA, *Annual Report 2004*, *op. cit*., pp. 54–57. See: Dr Mohamed ElBaradei, *Nuclear Terrorism: Identifying and Combating the Risks, loc. cit*.
The nuclear security section of the IAEA *Annual Report 2004* is available at: <http://www.iaea.org/Publications/Reports/Anrep2004/nuclear_security.pdf>. See also: IAEA, *Promoting Nuclear Security: What the IAEA is doing*, IAEA, Vienna, 2003, viewed 27 July 2006, <http://www.iaea.org/Publications/Factsheets/English/nuclsecurity.pdf>.

181 *ibid*., pp. 7, 54.

182 The Hon Alexander Downer MP, *Submission no. 33.2*, p. 8.

183 *ibid*. See also: IAEA, *Annual Report 2004, op. cit*., p. 54.

> The bulk of this nuclear security activity has occurred in the past three years. Since September 2001, working in Africa, Asia, Europe and Latin America, we have conducted more than 125 security advisory and evaluation missions, and convened over 100 training courses, workshops and seminars.[184]

8.174 ASNO noted that in 2002 the IAEA established a Nuclear Security Fund (NSF) specifically to handle voluntary contributions from IAEA members to fund the Agency's nuclear security program. As of July 2005, this extra-budgetary fund had received a total of US$36.7 million from 26 member states and one NGO, and in-kind contributions from 18 member states. Australia has contributed to the NSF and has furnished in-kind assistance. As noted by ANSTO, Australia also provides regional training and assistance on the security and physical protection of nuclear and other radioactive material.[185]

Conclusions

8.175 In addition to IAEA safeguards described in the previous chapter, Australia superimposes additional safeguards requirements through a network of bilateral safeguards agreements. The objectives of Australia's safeguards policy are to ensure that AONM is: appropriately accounted for as it moves through the fuel cycle; is used only for peaceful purposes; and in no way contributes to any military purpose.

8.176 Australia's policy also establishes criteria for the selection of countries eligible to receive AONM. The Committee notes that of the five cases where the IAEA has found countries in non-compliance with their safeguards agreements and reported the non-compliance to the UN Security Council, none of these cases involved countries eligible to use Australian uranium. Furthermore, as the previous chapter noted, from May 2005, NNWS must also make an Additional Protocol with the IAEA as a pre-condition for the supply of Australian uranium.

8.177 While the Committee notes that it simply cannot be absolutely guaranteed that diversion of AONM for use in weapons could never occur at some point in the future, nevertheless the Committee is satisfied that Australia's safeguards policy has been effective to date. The Committee concludes that the requirements in safeguards agreements are adequate and can see no reason for imposing additional requirements at this time.

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184 Dr Mohamed ElBaradei, *Nuclear Terrorism: Identifying and Combating the Risks, loc. cit.*

185 The Hon Alexander Downer MP, *Submission no. 33.2*, pp. 8–9.

8.178 The Committee rejects arguments that Australia's safeguards policy has been eroded and stripped of its potency over time. In particular, the Committee believes that the principles of equivalence and proportionality, which underlie nuclear fuel trade, simply reflect that, other than by establishing the entire nuclear fuel cycle in Australia and leasing fuel elements, it is impossible to track 'national atoms' once uranium from different sources is mixed together (e.g. in enrichment and fuel fabrication processes). It is for this reason that international practice is to designate an equivalent quantity as (Australian) obligated nuclear material. In this way, even if at some point AONM is co-mingled with unsafeguarded material, a proportion of the resulting material will be regarded as AONM corresponding to the same proportion of AONM initially. Thus, even if a stream of material is taken from a process for military purposes (e.g. from a conversion facility), the presence of the AONM will in no way benefit or contribute to the quantity or quality of the unobligated material. In any case, the facilities where AONM can be processed, including in the NWS, must be safeguarded and are eligible for IAEA monitoring and inspections.

8.179 The Committee notes the strong objection by some submitters to the reprocessing of spent fuel containing Australian-obligated plutonium. While the Committee agrees that the existence of stocks of separated plutonium does represent a possible proliferation danger, it notes that reprocessing used fuel has a number of important advantages that must also be considered. Specifically, reprocessing and plutonium recycling enables a far more efficient use of the uranium fuel, extending by about one third the amount of energy a country can obtain from the uranium they purchase. Furthermore, reprocessing and use of MOX fuel significantly reduces the amount of waste that must be disposed of. It strikes the Committee as somewhat curious that groups normally so in favour of energy efficiency and recycling will not countenace these same benefits when associated with the use of uranium.

8.180 Further to the discussion in the previous chapter, the Committee also notes that reprocessing technologies are now being developed in which plutonium is not fully separated, but remains mixed with uranium and highly radioactive materials, thus eliminating this proliferation danger while enabling plutonium recycling. The Committee notes that Australia is free to revoke consents for reprocessing at any time, if necessary. The Committee suggests that the issue of so-called plutonium stockpiling continue to be monitored by the Australian Government and that permission for reprocessing should be kept under review.

8.181 The Committee concludes that there is little or no potential for the diversion of AONM for use by terrorists, or for AONM and other

Australian radioactive materials to be used in 'dirty bombs'. In particular, the Committee notes that Australia's conditions for supply of AONM include an assurance that internationally agreed standards of physical security will be applied to nuclear materials in the country concerned.

8.182 The Committee was informed of the recent strengthening, under the IAEA's auspices, of several conventions and guidelines to protect against acts of nuclear terrorism, including significant amendments to the CPPNM and the Code of Conduct for Safety and Security of Radioactive Sources.

8.183 The Committee is pleased to note that Australia has again been at the forefront in negotiating these outcomes, as well as contributing to nuclear security initiatives in the region, such as leading a project to ensure the security of radioactive sources.

8.184 The Committee welcomes the assistance being provided by the IAEA in implementing measures to guard against thefts of nuclear and other radioactive material and to protect related facilities. This assistance has included its INSServ and IPPAS missions to member states.

Exports of uranium to China

8.185 While the Committee understands the concerns expressed by some submitters about the added risks for export of uranium attendant upon the absence of a fully 'open society' in China and its allegedly poor proliferation record, the Committee nonetheless concludes that such concerns should not prevent sales of Australian uranium to China.

8.186 The Committee is confident that sales of uranium will not, either directly or indirectly, contribute to any military purpose in China. Assurance that AONM will not be used in weapons programs is underpinned by China's preparedness to enter into a treaty-level commitment with Australia to this effect and the safeguards arrangements that will apply to AONM. The Committee notes that the facilities in which AONM is to be processed in China will be subject to IAEA monitoring. It is also the case that while Australian uranium attracts extensive safeguards, some of China's alternative sources of uranium supply may not attract such stringent safeguards.

8.187 While China has not officially confirmed the report, ASNO states that China ended production of fissile material for nuclear weapons around 1991. The Committee notes that, as with Australia's other bilateral safeguards agreements, Australia retains the right (in Article XII) of the Agreement to 'suspend or cancel further transfers of nuclear material' should any of the provisions of the Agreement not be complied with.[186] Naturally, the Committee concludes that if Australian uranium is ever diverted for weapons programs in China then the Australian Government should immediately terminate sales of uranium. Furthermore, while it is difficult to see how the provision could be enforced, the Agreement also states that Australia may 'require the return of nuclear material' if corrective measures are not taken within a reasonable time.[187]

8.188 As discussed in chapters four and nine, the Committee's support for sales of uranium to China is underpinned by the fact that use of nuclear power will aid in China's development and help to address the global energy imbalance, while also earning export income for Australia. Use of Australia's uranium will fuel the generation of base-load electricity in China in a manner that is far less carbon intensive than the alternatives and this will be of unquestionable global environmental benefit.

Possibility of uranium exports to India

8.189 The Committee notes that the proposed US-India nuclear cooperation agreement will have a number of important non-proliferation benefits, including that it will:

- expand the application of IAEA safeguards in India;
- allow the IAEA enhanced access rights;
- the majority of India's nuclear activities will be under safeguards; and
- India's very significant civil nuclear expansion will now be undertaken with heightened safety as it will be able to purchase more advanced nuclear technology.

8.190 The Committee notes that, in addition to the support the agreement has received from the Australian and other governments, the Director General of the IAEA has also welcomed the agreement, noting that it will 'bring India closer as an important partner in non-proliferation' and that it will represent a 'step forward towards universalistion of the international safeguards regime.'[188] The Committee also believes that the agreement is a positive development and particularly welcomes the increased transparency of India's civil nuclear program that will result.

8.191 The Australian Government has been asked to consider permitting sales of uranium to India. As India is not a signatory to the NPT, a decision to permit sales would require a departure from Australia's uranium exports

186 ASNO, *Agreement Between the Government of Australia and The Government of the People's Republic of China on the Transfer of Nuclear Material*, *op. cit.*, p. 7.

187 *ibid*.

188 Dr Mohamed ElBaradei, *IAEA Director General Welcomes U.S. and India Nuclear Deal, loc. cit.*

policy of almost 30 years standing—not to permit sales of uranium to states that are not party to the NPT.

8.192 The Committee notes that there are sound reasons to allow an exception to Australia's exports policy in order to permit uranium sales to India. Among these is the widely held view that India has consistently supported the objective of non-proliferation—unlike some other states that *are* NPT parties. It is conceivable that uranium could be supplied to India, for use in safeguarded reactors, in a way that does not undermine the non-proliferation regime. However, the Committee appreciates that this is a complex issue and does not wish to make a recommendation on the matter.

8.193 While the Committee believes that the issue should be subject to further examination, maintaining the integrity of the non-proliferation regime must remain the top priority and guiding principle for Australia's uranium exports policy. The Committee's view is that Australia's actions must not undermine the non-proliferation regime and the fundamental importance of the NPT. Accordingly, there would need to be compelling arguments to grant an exception to India.

8.194 Australia's position on this matter may have added significance in that, as potentially the world's largest uranium producer, it could carry a power of example to other suppliers. Furthermore, for the long-term stability and reputation of the Australian uranium industry, the Committee believes that—if at all possible—a bipartisan position on the India question should be developed.

8.195 The question of whether Australia should or should not supply uranium may of course become somewhat academic if the NSG decides to grant India an exception to its Guidelines and other countries begin to supply, as Russia apparently already has.

8.196 In the following chapter, the Committee turns to consider the strategic importance of Australia's uranium resources.

9

Strategic importance of Australia’s uranium resources

> *There is an overwhelming case for acknowledging the strategic value of Australian’s uranium resources by overturning outmoded antagonistic attitudes to nuclear power and permitting development of resources in accordance with global market demand.*[1]

1 Paladin Resources Ltd, *Submission no. 47*, p. 5.

Key messages —

- **Uranium is Australia's second largest energy export in terms of contained energy content.**
- **Uranium is an immensely concentrated source of energy—one tonne of uranium oxide generates the same amount of energy as 20 000 tonnes of black coal. The uranium produced from just one of Australia's mines each year—Ranger, in the Northern Territory—contains sufficient energy to provide for 80 per cent of Australia's total annual electricity requirements, or all of Taiwan's electricity needs for a year. Olympic Dam in South Australia contains uranium equivalent in energy content to 4.5 times the energy contained in the entire North-West Shelf gas field—25 billion tonnes of steaming coal.**
- **While Australia is well endowed with energy resources for its own needs, other countries are not so fortunate. These include developing countries such as China and India. As a matter of energy justice, Australia should not deny countries who wish to use nuclear power in a responsible manner the benefits from doing so. Neither should Australia refuse to export its uranium to assist in addressing the global energy imbalance and the disparity in living standards associated with this global inequity.**
- **Expanded mining and export of uranium will have economic and other benefits for the nation, the states that permit uranium resources to be developed and the regional communities supporting the mines.**
- **A proposal to expand Olympic Dam would increase South Australia's Gross State Product by about $1.4 billion and the number of jobs associated with the mine would increase by about 8 400.**
- **The value of Australia's undeveloped uranium resources is conservatively estimated at $32 billion. Restrictions on developing Australia's locked up uranium resources now involve a significantly higher opportunity cost as the price of uranium has trebled since 2003 and is continuing to rise.**
- **If Australia fails to export uranium and to capitalise on its opportunities, uranium will inevitably be supplied to the market by other countries, including those without Australia's safeguards commitments and other regulatory requirements.**

Introduction

9.1 In addition to its greenhouse gas emission benefits, which were discussed in chapter four, evidence presented to the Committee suggested that the strategic importance of Australia's uranium resources derives from the:

- significance of the resource as one of Australia's major energy exports;
- energy security benefits that uranium can provide those countries that choose to adopt nuclear power;
- potential for Australia's uranium exports to assist in addressing the global energy imbalance;
- economic benefits that may be obtained from uranium mining, particularly for state economies and regional communities;
- economic significance of Australia's undeveloped uranium resources; and
- Australia's role as a major uranium exporter in the global nuclear fuel cycle.

This chapter considers each of these points in turn. The potential for Australia's uranium resources to underpin the establishment of domestic fuel cycle service industries is considered in chapter 12.

Energy exports

> *These resources are of exceedingly great future importance to Australia, being, in terms of energy, equivalent to many billions of tonnes of coal.*[2]

9.2 The strategic importance of Australia's uranium resources derives primarily from its role as one of the nation's major energy exports, particularly given predictions that the world's energy needs will increase by 1.7 per cent annually and double in the period to 2050.[3] Moreover, as described in chapter two, the global demand for electricity is forecast by the International Energy Agency (IEA) to grow at an annual rate of 2.7 per cent to 2030, faster than overall energy demand, and is likely to be driven by the industrial modernisation of India and China.[4] A quarter of the world's projected increase in electricity production to 2030 is expected to

2 Mr John Reynolds, *Submission no. 5*, p. 3.

3 See for example: Submarine Institute of Australia, *Submission no. 21*, p. 4; UIC, *Submission no. 12*, p. 2.

4 Nova Energy Ltd, *Submission no. 50*, p. 1.

occur in China.[5] The role of Australia's uranium as a significant energy export was recognised in the Australian Government's energy white paper, *Securing Australia's Energy Future*, published in 2004.[6]

9.3 Uranium currently comprises just over 40 per cent of Australia's total energy exports in terms of contained energy content—second only to black coal. In 2004–05, Australia's uranium exports represented the energy equivalent of 5 287 petajoules, compared to 6 595 for coal, 555 for crude oil, 576 for liquid natural gas (LNG) and 73 for liquid petroleum gas.[7]

9.4 As noted in chapter four, uranium is an immensely concentrated source of energy: nuclear fuel from one tonne of uranium oxide (U_3O_8) can produce 40 000 megawatt-hours of electricity, containing the same amount of energy as 20 000 tonnes (t) of typical black coal, 80 000 barrels of oil or 13 million cubic metres of gas.[8] Each kilogram of U_3O_8 produces 500 000 megajoules (MJ) of heat in a conventional reactor, compared with 39 MJ for gas, 45 MJ for oil and 10-30 MJ for coal—that is, uranium contains some 10 000 times more energy per kilogram of fuel than traditional fossil fuel sources .[9]

9.5 The energy benefits of the uranium produced from the three existing Australian uranium mines are demonstrated by the following:

- the current economically-recoverable uranium at Olympic Dam has 4.5 times the amount of energy contained in the entire Northwest Shelf Gas Project—the equivalent of 25 billion tonnes of steaming coal;[10]
- annual production from the Beverley mine produces the same amount of energy as 16 million tonnes of coal and will generate electricity sufficient for more than four million people per year;[11] and

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5 IEA, *World Energy Outlook 2004*, OECD/IEA, Paris, 2004, p. 193.

6 Energy Task Force, *Securing Australia's energy future*, Commonwealth of Australia, Canberra, 2004, p. 46, viewed 30 May 2006, <http://www.dpmc.gov.au/publications/energy_future>.

7 K Donaldson, *Australian energy consumption and production, 1974-75 to 2004-05*, Australian Bureau of Agricultural and Resource Economics, Canberra, 2006, viewed 15 June 2006, <http://www.abareconomics.com/interactive/energy/index.html >. See also: Minerals Council of Australia (MCA), *Submission no. 36*, pp. 1, 8; John Reynolds, *loc. cit.*; Department of the Environment and Heritage (DEH), *Submission no. 55*, p. 5.

8 Mr Alan Eggers (Summit Resources Ltd), *Transcript of Evidence*, 3 November 2005, p. 2; UIC, *op. cit.*, p. 10; Paladin Resources Ltd, *Submission no. 47*, p. 4; AMP Capital Investors Sustainable Funds team (AMP CISFT), *Exhibit no. 65*, *The nuclear fuel cycle position paper*, p. 13. Areva estimated that half a tonne of enriched U_3O_8 would produce as much energy as would 50 000 t of coal: Areva, *Submission no. 39*, p. 7.

9 UIC, *op. cit.*, pp. 3, 10; Professor Leslie Kemeny, *Exhibit no. 43*, *Pseudo-science and lost opportunities*, p. 54.

10 UIC, *op. cit.*, pp. 2-3, 10-13. See also: UIC, *World Energy Needs and Nuclear Power*, UIC, Melbourne, July 2002, viewed 3 June 2005, <www.uic.com.au/nip11.htm>.

- annual production from the Ranger mine, of over 5 000 t U_3O_8, is sufficient in terms of contained energy to supply over 80 per cent of Australia's annual electricity requirements, or to power Taiwan in its entirety for a year.[12]

Further, Australian uranium was used to generate 3.6 per cent of the USA's total electricity in 2004 and generates approximately two per cent of the world's entire electricity production from all sources—an immense amount of energy.[13]

9.6 Summit Resources proposes to produce some nine million pounds of U_3O_8 per year from its Mt Isa deposits and this would be sufficient to supply ten, 2 000 megawatt power stations—equivalent to replacing 76 million tonnes black coal (which would produce 160 million t of greenhouse gases).[14]

9.7 The International Ministerial Conference, *Nuclear Power for the 21st Century*, held in March 2005, affirmed the strategic importance of nuclear energy in meeting growing energy needs in an environmentally responsible manner.[15]

9.8 As discussed in chapter two, nuclear power currently supplies 16 per cent of the world's electricity and nuclear capacity is expected to increase. However, the International Energy Agency (IEA) predicts that the share of nuclear power in total electricity generation will decline in the medium to longer term (to 12 per cent by 2030).[16] This prediction is based on a scenario in which existing plants will close on schedule, and that no new plants are built beyond those already under construction or firmly planned. In contrast, the International Atomic Energy Agency (IAEA) has published a forecast in which nuclear power generation increases 2.5 times by 2030 to account for 27 per cent of world electricity generation, and for nuclear power output to quadruple by 2050.[17]

9.9 It was argued that regardless of the forecast for nuclear power adopted, uranium remains one of the nation's most important and strategic energy and export assets, particularly given that Australia holds a significant

11 Heathgate Resources Pty Ltd, *Exhibit no. 57, Heathgate Resources Pty Ltd – Beverley Uranium Mine*, p. 2.

12 Energy Resources of Australia Ltd (ERA), *Exhibit no. 76, What is it really like to operate a large uranium mine in Australia?*, p. 4.

13 Paladin Resources Ltd, *op. cit.*, p. 5; Mr John Carlson (ASNO), *Transcript of Evidence*, 10 October 2005, p. 17.

14 Mr Alan Eggers, *op. cit.*, p. 2.

15 The Honourable Alexander Downer MP, *Submission no. 33*, pp. 6–7.

16 Australian Bureau of Agricultural and Resource Economics (ABARE), *Submission no. 14*, p. 4.

17 MCA, *op. cit.*, pp. 1, 8.

share of the market in regions where nuclear power is expanding, notably North Asia. For example, China plans to more than quadruple its nuclear power capacity to 40 gigawatts electrical (GWe) (to four per cent of total projected electricity demand) by 2020.[18]

9.10 In relation to exports of uranium to China, Cameco noted that the Canadian Government has already negotiated a bilateral agreement for sales of uranium to China and has also exported nuclear reactor technology to that country. Similarly, the US Government has permitted Westinghouse and General Electric to sell their reactor technology to China.[19]

9.11 The Australian Nuclear Association (ANA) argued that the size of Australia's uranium resources means that:

> It is almost self-evident that if a country owns around 40 per cent of the world's resources, whether it be uranium or nickel or copper, that must have great strategic importance in the world's thinking if that is a material which is an important resource for energy production— in this case, mainly electricity production. Even 25 per cent production of the world's low-cost uranium sold to the world is a very important strategic amount. It is likely that this percentage will increase even more, and therefore it will become even more strategically important to many countries that have invested large amounts of money in putting in place nuclear power programs in their own countries. It is almost self-evident that it must have great strategic importance.[20]

9.12 As described in chapter three, should the proposed expansion of Olympic Dam proceed, this would double Australia's current national uranium production.[21] Olympic Dam would also become the world's largest producer, accounting for over 20 per cent of total world uranium production.[22]

18 UIC, *op. cit.*, p. 12.
19 Mr Jerry Grandey (Cameco Corporation), *Transcript of Evidence*, 11 August 2005, p. 4.
20 Dr Clarence Hardy (ANA), *Transcript of Evidence*, 16 September 2005, p. 52.
21 Mr Aden McKay (Geoscience Australia), *Transcript of Evidence*, 5 September 2005, p. 3.
22 BHP Billiton Ltd, *Exhibit no. 78, Presentation by Dr Roger Higgins*, p. 3.

Energy security

> *If international tensions are to be reduced and the prospects of a peaceful global environment enhanced, the importance of national and international energy security cannot be over-emphasised.*[23]

9.13 Secure energy supplies are vitally important, both for industrialised and developing countries. As discussed in chapter four, nuclear power has relatively low operating and fuel costs. These costs are controllable. The price of the electricity produced is relatively insensitive to fluctuations in the uranium price. These features mean that:

> … countries that go nuclear have a security of supply. Throughout the lifetime of the plant the fuel cost is not going to change very much, so they can guarantee some values for their electricity costs over that period.[24]

9.14 Mr Jerry Grandey, President of Cameco Corporation, also pointed to the energy security benefits of uranium in an environment where fossil fuel prices are rising and where oil is largely sourced from unstable regions of the world:

> Nothing focuses one's attention like $50 or $60 oil. Nothing focuses one's attention like having half the US defence budget dedicated to making sure that oil continues to flow. All of a sudden, security of supply—and uranium is quite advantageous in that regard—becomes a tremendous benefit.[25]

9.15 Australia's potential contribution to maintaining a secure supply of energy is related to its geographical location and political stability. As noted by the UIC, vast resources of traditional fossil fuels (more than 60 percent of the world's oil and 40 per cent of its gas) are concentrated in the Middle East—a region where 'historically, political instability has translated into very volatile prices.'[26] The MCA concurred with this view, noting that geopolitical tensions have contributed to significant rises in fossil fuel prices, ultimately increasing the price of electricity:

23 Australian Science and Technology Council (ASTEC), *Australia's role in the nuclear fuel cycle — A report to the Prime Minister*, Australian Government Publishing Service, Canberra, 1984, p. 5. Commonly referred to as the 'Slatyer report', after the Chairman of the Council, Professor R O Slatyer.

24 Dr Ron Cameron (ANSTO), *Transcript of Evidence*, 13 October 2005, p. 9.

25 Mr Jerry Grandey, *op. cit.*, p. 17.

26 UIC, *op. cit.*, p. 9. See also Mr Ian Hore-Lacy, *op. cit.*, p. 89.

> These price increases, representing 50% for oil, 100% for coal and 50% for natural gas in Europe, and 100% in the United States, have pushed electricity prices up by 15% to 20% on average.[27]

9.16 In contrast, uranium is plentiful in many regions around the world (notably, North America, Europe, Africa and the Asia-Pacific) and that, therefore, 'in the event of interruption to production in one region, the impact on the entire market would be much less severe than for oil or gas.'[28]

9.17 DEH also noted that countries expanding the use of nuclear power are doing so 'generally, for reasons wider than greenhouse gases. It is generally to do with having a secure energy supply and having a wide variety of supplies to protect energy security.'[29]

9.18 The MCA noted that energy demand will grow as China and India continue to develop.[30] It was suggested that the demand for Australian uranium would intensify, as China and India increasingly look to uranium to provide a secure source of energy.[31]

9.19 Australia, by virtue of its abundant uranium resources, could therefore make a significant contribution to the security of global energy supplies by being a reliable, long-term uranium supplier.[32]

Global energy imbalance

9.20 A number of submitters highlighted, with concern, the global energy imbalance. For instance, Arafura Resources noted that:

> … power generation and consumption is heavily skewed toward developed countries. Of all the electricity generated across the world 75% is consumed by developed and industrialised countries while the remaining 25% is used in underdeveloped or developing countries. But demand by developing countries for power generation is constantly increasing as they look to improve their domestic economies through industrial development.[33]

27 MCA, *op. cit.*, p. 3.
28 UIC, *loc. cit.*
29 Mr Barry Sterland (DEH), *Transcript of Evidence*, 10 October 2005, p. 14.
30 MCA, *op. cit.*, p. 8.
31 *ibid.*
32 ASTEC, *loc. cit.*
33 Arafura Resources NL, *Submission no. 22*, p. 2.

9.21 Information published by the IEA states that 1.6 billion people worldwide currently have no access to electricity and the demand for electricity from developing countries is expected to more than triple by 2030.[34]

9.22 The Director General of the IAEA, Dr Mohamed ElBaradei, has noted the importance of nuclear energy in correcting the imbalance of energy availability between developed and developing countries:

> Per capita electricity consumption in Ghana is only about 300 kilowatt-hours per year, and in Nigeria it's closer to 70 kilowatt-hours per year … Contrast that with France, where per capita consumption is over 7300 kilowatt-hours per year … slightly less than the OECD average of 8000 kilowatt hours per year, and well below the consumption rates, for example, in Scandinavian countries.[35]

9.23 The Uniting Church (Synod of Victoria and Tasmania) submitted that there is a need to re-examine 'the glaring differences in the use of energy in the wealthier and poorer parts of the world.'[36] Notwithstanding this concern, the Uniting Church did not accept that nuclear energy is necessarily the solution to the global energy imbalance.[37]

9.24 The MCA observed that Australia is endowed with 'significant, diverse and high quality energy resources'.[38] Australia's own energy needs are well catered for as the country possesses 'some 800 years supply of lignite in Victoria, some 290 years supply of black coal in Queensland and NSW and large natural gas resources.'[39] Other countries, however, are not so fortunate and must import fuel to meet their electricity generation requirements. Among these are developing Asian countries, notably China.[40]

9.25 Evidence presented to the Committee stated that China intends to meet at least part of its growing demand for energy through a significant expansion of the use of nuclear power. As noted above, China is planning a fivefold increase in nuclear capacity to 40 GWe by 2020. The expansion will require the construction of two nuclear power plants every year over

34 IEA, *loc. cit.*; IEA, *CO_2 Emissions from Fuel Combustion 1971–2003*, IEA/OECD, Paris, 2005, p. xvii.

35 Dr Mohamed ElBaradei, *Nuclear Power: Preparing for the Future*, IAEA, Paris, 21 March 2005, viewed 19 May 2006, <http://www.iaea.org/NewsCenter/Statements/2005/ebsp2005n004.html>.

36 Uniting Church in Australia (Synod of Victoria and Tasmania), *Submission no. 40*, p. 6.

37 *ibid.*

38 MCA, *op. cit.*, p. 10.

39 *ibid.*

40 *ibid.*; Mr Ian Hore-Lacy, *op. cit.*, p. 89.

the period.[41] India is currently constructing eight nuclear power plants and intends to triple nuclear generating capacity to 20 GWe by 2020. India intends that by 2050 nuclear power will contribute 25 per cent of the country's electricity—a hundredfold increase on 2002 nuclear generating capacity.[42]

9.26 Arafura Resources argued that the global energy imbalance has meant that:

> Generating power from uranium must become an essential part of the process of sustaining economic growth, maintaining the developed world's lifestyle, improving the living standards of developing economies and saving the environment. A cheap clean source of power will allow these countries to develop their own natural resources and help lift their populations out of the poverty rut.[43]

9.27 Similarly, Mr Andrew Parker submitted that 'Australia should ensure that enough uranium and thorium is available to our regional trading partners who are not well endowed with either oil or uranium reserves.'[44]

Economic benefits derived from Australia's uranium industry

> *A responsible approach to our great natural resource could reap Australia major economic benefits.*[45]

9.28 The strategic importance of Australia's uranium resources lies partly in the extent to which they can generate economic benefits. Uranium exploration and mining in Australia has produced the following economic benefits:

- employment;
- regional development and infrastructure;
- export earnings;
- benefits for Aboriginal communities;
- royalties, taxes and fees paid to governments;

41 Mr Alan Eggers, *op. cit.*, p. 1.

42 UIC, *Nuclear Power in India and Pakistan*, Nuclear Issues Briefing Paper No. 45, viewed 1 June 2006, <http://www.uic.com.au/nip45.htm>.

43 Arafura Resources NL, *op. cit.*, pp. 4–5. See also: Dr Mohamed ElBaradei, *loc. cit.*

44 Mr Andrew Parker, *Submission no. 3*, p. 3.

45 Arafura Resources NL, *op. cit.*, p. 8.

9.29 Southern Gold predicted that further expansion of the industry would result in numerous economic benefits:

> Further development of the industry would involve large-scale construction projects, investment in plant and equipment, community infrastructure, employment creation, increased Government revenues and greater export earnings.[46]

Employment

9.30 Heathgate Resources noted that although the company is the smallest and the newest uranium producer in Australia, it directly employs 100 people and, together with those indirectly employed, a total of almost 300 people—almost all of whom are located in regional Australia.[47] The company expressed pride in the fact that it is the largest private employer of Aboriginal people from the Flinders Ranges, with approximately 25 per cent of the mine site workforce drawn from this area.[48]

9.31 ERA is also a significant employer in the Northern Territory (NT), with an annual payroll of $45 million:

> The company is the dominant contributor to the Alligator rivers regional economy, employing more than 300 permanent, full-time and fixed-term contract staff, including at present 45 Aboriginal staff. Many more contractors, subcontractors and local businesses are also dependent on the company's business.[49]

9.32 Olympic Dam in South Australia currently employs some 1 750 people at the mine site, with a further 6 240 jobs indirectly generated by the mine across the State.[50]

9.33 Nova Energy estimated that $1 million of uranium industry expenditure generates 13 full time equivalent (FTE) jobs in Australia.[51] It assessed that uranium mining in Western Australia (WA), if permitted, would generate 20 800 FTE positions nationally.[52]

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46 Southern Gold Ltd, *Submission no. 54*, pp. 7–8.

47 Mr Mark Chalmers (Heathgate Resources), *Transcript of Evidence*, 19 August 2005, p. 96; Heathgate Resources, *loc. cit.*

48 *ibid.*

49 Mr Harry Kenyon-Slaney (ERA), *Transcript of Evidence*, 24 October 2005, p. 46.

50 The South Australian Centre for Economic Studies (SACES), *The Gross Economic Impact of the Proposed Expansion of Olympic Dam on the South Australian Economy*, SACES, Adelaide, 2005, pp. i–ii.

51 Nova Energy Ltd, *op. cit.*, p. 13.

52 *ibid.* See also: Eaglefield Holdings Pty Ltd, *Submission no. 18*, p. 5; Compass Resources NL, *Submission no. 6*, p. 4.

Regional development and infrastructure

9.34 The Director of National Parks, Mr Peter Cochrane, noted that the Ranger mine generates a range of benefits for the people living in the region and is extremely important for the viability of the Jabiru township

> I understand that nearly half the current population of Jabiru is associated with the mine and mineworkers' families, so the mine has a very significant economic benefit for the region. Clearly, the town is of a sufficient size to warrant the current school, health clinics and other key services which my staff and their families enjoy, as do Aboriginal residents of the park and the wider region. So the mine has a significant economic impact on the region.

9.35 Moreover, Mr Cochrane argued that if the mine were to close the costs to maintain the town, including electricity generation, would then have to be borne by government:

> … if half the town population disappears with the closure of Ranger uranium mine then those services—presumably—will not be provided at anywhere near the current level. That would have an impact on the region and on my capacity to staff the park as well … The power generation for the town is currently supplied by the mine. That alone would be a significant impost in the future on some government or other entity that would be responsible for providing power to the township and the surrounds. I cannot comment on what a halving of the town population would mean for things like the viability of the supermarket or banking services et cetera. But my guess is that as soon as you start halving the size of the town you probably have a greater impact than halving the size of the associated services.[53]

9.36 ERA credits its work in Jabiru as galvanising:

> … much of the infrastructure in the area — roads, the power station, housing and of course the money that is returned to the area through employment, services and taxes.[54]

> The company has provided much of the infrastructure for the town of Jabiru, an important service centre for the Kakadu National Park.[55]

9.37 In addition to the infrastructure and services that support the mine and the Jabiru township, such as roads and the construction of the power

53 Mr Peter Cochrane (DEH), *Transcript of Evidence*, 10 October 2005, p. 8.

54 ERA, *op. cit.*, p. 9.

55 Mr Harry Kenyon-Slaney, *op. cit.*, p. 46.

plant, Mr Harry Kenyon-Slaney noted that ERA is also involved in supporting a range of social programs with the local community.[56]

9.38 Areva detailed the economic benefits of the uranium industry for regional areas:

> … the most significant contribution of the industry is at a more regional level where it significantly impacts on:
>
> a) Housing and infrastructure, through the establishment of mining facilities and access roads, railways …
>
> b) Local employment, usually promoted as part of the various approval processes
>
> c) Health monitoring of local employees
>
> d) Training and education: ongoing training of on-site personnel is considered standard practice in the mining industry and the uranium mining industry is no exception, with a special emphasis on occupational health and safety
>
> e) Sports and recreation, usually benefiting not only the mine site but also surrounding communities.[57]

9.39 The Northern Territory Minerals Council (NTMC) cited a study entitled the *Contribution of the Ranger uranium mine to the Northern Territory and Australian economies*, which found that the Ranger mine and directly related activities accounted for seven per cent of the Territory's economic activity between 1981–82 and 1991–92, some $5.3 billion in 1991–92 terms. The NTMC asked the Committee to:

> Imagine what one new uranium mine of that size could do for the Northern Territory, its economy and its people, let alone if we could have two more mines.[58]

9.40 Eaglefield Holdings, owners of the Mulga Rock deposit (MRD) in the eastern regions of the WA goldfields, pointed out that uranium deposits, particularly in WA, tend to be located away from existing mining areas.[59] Development of uranium deposits could therefore have regional benefits and support the development of other resource projects:

> As a consequence of that, the development of uranium deposits, particularly in WA, would see the development of infrastructure in parts of Western Australia which are presently devoid of any infrastructure. I am talking primarily about access,

56 *ibid.*, p. 55; ERA, *op. cit.*, p. 4.

57 Areva Group, *op. cit.*, p. 15.

58 Ms Kezia Purick (NTMC), *Transcript of Evidence*, 24 October 2005, pp. 32–33.

59 Mr Michael Fewster (Eaglefield Holdings Pty Ltd), *Transcript of Evidence*, 23 September 2005, p. 24.

> accommodation and other types of infrastructure. A consequence of the installation of that infrastructure would be to allow the development of other resource projects of great benefit to the region.[60]

Export income

9.41 The Association of Mining and Exploration Companies (AMEC) argued that uranium mining makes a significant contribution to the nation's finances by generating export income:

> Australia's uranium export revenue was A$410 million in 2004, and the industry is thus worth some A$1 billion per year to the Australian economy, and is forecast to increase.[61]

9.42 The UIC noted that in 2004–05 uranium exports were worth A$475 million. Over the five years to mid 2005, Australia exported 46 600 tonnes of uranium oxide with a value of over $2.1 billion to eleven countries around the world.[62]

9.43 Arafura Resources highlighted the dramatic increase in uranium export revenue over recent years:

> Between 2002 and 2004 our uranium exports generated about A$400 million per annum in revenue when uranium prices were between US$10 and US$15 per lb. Uranium prices have now increased to almost US$25 per lb which means our exports have grown in value to A$650 million.[63]

9.44 Eaglefield Holdings also suggested that uranium mining in WA could also increase exports of LNG and other commodities.[64] The major export markets for uranium are also major or emerging markets for LNG, a commodity in which Australia has a smaller competitive advantage. Eaglefield suggested that sales of uranium to such markets could be made contingent on purchases of LNG and other commodities.[65]

9.45 Eaglefield Holdings claimed that uranium mining in WA could deliver economic benefits through the establishment of related industries. It submitted that the production of uranium from the MRD would create

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60 *ibid.* See also: Eaglefield Holdings Pty Ltd, *loc. cit.*, p. 5.

61 AMEC, *Submission no. 20*, p. 4.

62 UIC, *Australia's Uranium and Who Buys It*, Nuclear Issues Briefing Paper No. 1, viewed 1 June 2006, <http://www.uic.com.au/nip01.htm>.

63 Arafura Resources NL, *op. cit.*, p. 7.

64 Eaglefield Holdings Pty Ltd, *op. cit.*, p. 6.

65 *ibid.*

industries for the production of related commodities, such as scandium and synthetic oil.[66]

9.46 A number of submitters highlighted the potential contribution of uranium mining to the Australian economy, particularly in relation to the national balance of payments.[67] The UIC noted the importance of uranium exports for the national economy, particularly through foreign investment and in the event of a downturn in demand for coal and other fossil fuel exports:

> In terms of Australian domestic strategic considerations, uranium is an important 'hedge' for the balance of payments. It will help offset the negative impact on Australia's coal exports of any international move to reduce global carbon emissions, with any fall in coal-fired power generation stimulating demand for alternative fuel sources such as uranium.[68]

9.47 Paladin Resources argued that the uranium and coal industries are complementary:

> Australia's uranium exports "neutralise" the carbon content of Australia's thermal coal exports by generating in our customers' countries an amount of carbon-free electricity to balance the inevitable carbon emissions of burning the coal equivalent.[69]

Indeed, Paladin contended that uranium exports should earn credits against carbon taxes, where these exist.[70]

Benefits for Aboriginal communities

9.48 Southern Gold predicted that an expanded uranium industry would have benefits for Aboriginal groups and regional Australia, through the creation of employment, provision of royalties and establishment of new infrastructure.[71]

9.49 ERA pays 4.25 per cent of net sales via the Commonwealth to the Aboriginal Benefits Trust Account for distribution to the Aboriginal owners. In addition, ERA pays 1.25 per cent of net sales via the Commonwealth to the NT to cover the costs of administration.[72] During 2005, ERA paid $10.2 million in royalties from the Ranger operation to the

66 *ibid.*, pp. 6–9.

67 See for example: UIC, *op. cit.*, pp. 2, 12; Jindalee Resources Ltd, *Submission no. 31*, p. 4; AMEC, *op. cit.*, p. 6; Summit Resources Ltd, *Submission no. 15*, pp. 7, 18, 36.

68 UIC, *op. cit.*, p. 12.

69 Paladin Resources Ltd, *op. cit.*, p. 4.

70 *ibid.*, p. 5.

71 Mr Cedric Horn (Southern Gold Ltd), *Transcript of Evidence*, 19 August 2005, p. 13.

72 Geoscience Australia, *Submission no. 42*, p. 8.

Australian Government, with these funds ultimately distributed to the Traditional Owners, the Mirrar Gundjeihmi people.[73]

9.50 Heathgate Resources pays over $1 million per year in native title royalties to the Indigenous community. In addition to the royalty payments, Heathgate also argued that the establishment of the Beverley uranium mine has delivered employment benefits to the Adnyamathanha and Kuyani people, traditional claimants to the land, with Aboriginal persons from the local area comprising 25 per cent of Beverley's workforce. The company also makes community and administration payments.[74]

9.51 As the Northern Land Council (NLC) explained, sections 63 and 64 of the *Aboriginal Land Rights (Northern Territory) Act 1976* (ALRA) provide that amounts equal to mining royalties received by the Commonwealth or the NT governments from mining on Aboriginal land must be paid into the Aboriginal Benefits Account (ABA), with amounts received by the ABA distributed as follows:

- 40 per cent to meet the administrative costs of land councils (in such proportions as the Minister determines);[75]
- 30 per cent to the relevant land council to forward within six months to Aboriginal associations the members of which live in, or are the traditional Aboriginal owners of, the area affected by mining operations; and
- 30 per cent, as directed by the Minister, paid to or for the benefit of Aboriginals living in the NT.[76]

9.52 In the case of royalties from the Ranger operation, the NLC forwards payments to the Gundjeihmi Aboriginal Corporation (GAC). Thus, for royalties paid by ERA in 2005, the Traditional Owners were entitled to receive approximately $3.06 million.

9.53 However, the NLC argued that royalties are not substantial and are spread thinly. To increase the returns to Aboriginal people, it was argued repeatedly that land councils should be empowered under the ALRA to enter into commercial mining agreements with mining companies:

> People seem to think that there is a golden mile club out at Jabiru. The reality is that the money does not go very far at all. That is

73 Mr Harry Kenyon-Slaney, *op. cit.*, pp. 46, 55; ERA, *op. cit.*, p. 4. ERA, *2005 Annual Report*, p. 18. viewed 27 June 2006, < http://www.energyres.com.au/corporate/era-ar-2005.pdf>. See also: Nova Energy Ltd, *op. cit.*, pp. 12–13.

74 Heathgate Resources Pty Ltd, *Submission no. 49*, p. 3. See also: AMEC, *op. cit.*, p. 4.

75 Under proposed reforms to the ALRA, the amount currently distributed to land councils for administrative costs (40 per cent) will be abolished and replaced with annual appropriations.

76 NLC, *Submission 78.1*, p. 2.

> why we are talking today about the requirement for part 4 to allow us to enter into commercial mining agreements.[77]

Royalties, taxes and fees paid to governments

9.54 The uranium industry generates revenue for the government through the payment of various taxes and fees. As AMEC noted:

> Uranium mining contributes to the economy in the form of corporate and PAYE income taxes, indirect taxes and royalties …[78]

9.55 ERA stated that, in nominal terms, the company has paid more than $700 million in income taxes since the project commenced in 1980. During that period, the Ranger mine has paid a total of $220.9 million in nominal terms in royalties, which are levied at 5.5 per cent of sales revenue. In 2005, ERA paid $2.9 million in royalties to the Australian Government for distribution to the NT Government.[79]

9.56 Heathgate Resources stated that the Beverley uranium mine contributed some $50 million per annum to state economies, through the payment of royalties, taxes, wages and payments to suppliers.[80]

9.57 Eaglefield Holdings suggested that uranium mining royalties and other taxes paid to state governments reduce the taxation burden on the community.[81] It estimated that, in the event that uranium mining is permitted in WA, uranium mining could potentially deliver $30 million per annum, in royalties alone, to the state government.[82]

Proposed expansion of Olympic Dam

9.58 Chapter three described the proposed expansion of the Olympic Dam copper-uranium mine. The expansion will involve an investment of up to US$5 billion. During the four-year execution phase, the company will employ an average of 5 000 construction workers, with peaks of up to double this number. The expanded mine may require the construction of significant additional infrastructure, including a possible rail line from Pimba to the mine, a desalination plant and gas pipe lines from Moomba to Olympic Dam.[83]

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77 Mr Norman Fry (NLC), *Transcript of Evidence*, 24 October 2005, p. 24.

78 AMEC, *op. cit.*, p. 4.

79 Mr Harry Kenyon-Slaney, *op. cit.*, pp. 46, 55; ERA, *op. cit.*, p. 4; ERA, *2005 Annual Report, loc. cit.* See also: Nova Energy Ltd, *op. cit.*, p. 13.

80 Heathgate Resources, *Exhibit no. 57*, *op. cit.*

81 Eaglefield Holdings Pty Ltd, *op. cit.*, p. 5.

82 *ibid.*

83 Dr Roger Higgins (BHP Billiton), *Transcript of Evidence*, 2 November 2005, pp. 7, 16. See also: UIC, *op. cit.*, pp. 12–13.

9.59 A study commissioned by the mine's former owners, WMC Resources, estimated the economic impact the proposed expansion would have on the SA economy. At present, it is estimated that there are some 6 240 jobs associated with Olympic Dam throughout the State and 1 750 directly employed at the mine. With the expansion, direct employment would increase to 3 250, with 14 660 associated jobs in SA. Table 9.1 summarises the economic impact of the proposed expansion.

Table 9.1 Economic benefits of Olympic Dam and the proposed expansion

	Olympic Dam today	Expanded (2013+)
Direct employment at Olympic Dam	1 750 full-time	3 250 full-time (plus an average of 5 000 workers during the four-year construction phase)
Location	Roxby Downs 80% Fly-in-fly-out (FIFO) / Drive-in-drive-out (DIDO) 20%	Roxby Downs ~85% FIFO/DIDO ~15%
Indirect employment (associated with Olympic Dam throughout SA)	6 240	14 660
Sales revenue (per year)	$1.1 billion	$2.7 – 3.2 billion
Royalties (per year)	~$35 million	$70 – 80 million
Payroll tax (per year)	~$6 million	$9 – 10 million
Contribution to SA's overseas exports (per cent)	12%	~15%
Contribution to Gross State Product (GSP) ($ in 2004 prices and percentage of State GSP)	$1.04 billion (2% of GSP)	$2.43 billion (3% of GSP)

Source The South Australian Centre for Economic Studies (SACES), *The Gross Economic Impact of the Proposed Expansion of Olympic Dam on the South Australian Economy*, SACES, Adelaide, 2005; Michael Nossal, *Olympic Dam Development Study*, WMC Resources, Melbourne, 2004, p. 10; BHP Billiton, *Exhibit no. 56, Olympic Dam Development Pre-feasibility Study*, p. 18. Figures in Australian dollars.

9.60 The aggregate impact of the expanded mine on gross state product (GSP) would be of the order of three per cent of South Australia's GSP. Production from the mine would account for approximately 15 per cent of the State's overseas exports:

> Thus Olympic Dam's contribution to South Australia's GSP would increase by about $1.4 billion and the number of jobs associated with its activities would increase by about 8,400.[84]

84 SACES, *loc. cit.*

9.61 In addition to these benefits, the expanded mine would generate up to three times the current sales revenue (up to A$3.2 billion annually), double the current royalty payments (to $80 million). Payroll tax would also rise significantly.[85]

Valhalla, Skal and Andersons

9.62 Summit Resources, which owns uranium deposits in Queensland that it is currently prevented from developing, is another example of the potential significance of uranium mines to regional economies. Once a mining lease is granted, Summit Resources intends to initially produce six million pounds of U_3O_8 per year (2 750 t). This will make it Australia's third largest uranium mine. After three years, the company proposes to scale up production to nine million pounds (4 000 t) per year. The mine life will initially be 10 years (based on current measured and indicated resources), but there is potential for this to be extended to over 20 years.[86]

9.63 The company has estimated that it will outlay $400 million in capital expenditure in the district of the mine and spend another $600 million in operating costs, largely on wages and contractors in the district. Export revenues would be $2.5 billion over six years. The company will employ some 600 people in the initial mining and construction phase and about 400 to 500 full time employees on an on-going basis. In addition, Summit will generate royalties in the order of $55 million over six years as well as taxation revenues.[87]

Economic significance of Australia's undeveloped uranium resources

9.64 Evidence to the Committee emphasised the value of Australia's undeveloped uranium resources. Eaglefield Holdings stated that:

> A Government should be mindful of the enormous value and income potential of these resources to the people of the state if considering policies that seek to sterilise them.[88]

9.65 Areva provided an estimate of the value of the major undeveloped uranium resources in each state, which are listed in table 9.2. Areva estimated the possible revenues that might be earned from the resources

85 Mr Michael Nossal, *Olympic Dam Development Study*, WMC Resources Ltd, Melbourne, 2004, p. 10.
86 Mr Alan Eggers, *op. cit.*, pp. 9–10.
87 *ibid.*, p. 5; Summit Resources Ltd, *Exhibit no. 77, Presentation by Mr Alan Eggers*, p. 32.
88 Eaglefield Holdings Pty Ltd, *op. cit.*, p. 5.

at over A$19 billion. However, this amount is likely to significantly underestimate the current value of the resources because the estimates were made assuming a U_3O_8 price of US$26 per pound, while the spot price has now risen to US$43 per pound.[89]

Table 9.2 Possible revenues from uranium sales for the most significant undeveloped resources in Australia

State	Orebody	Potential in-ground value (million $A)	Total value per state (million $A)
NT	Jabiluka Koongarra Angela	10 500 917 506	11 923
WA	Kintyre Yeelirrie Mulga Rock Manyingee Oobagooma Lake Way	1 580 2 300 660 ~300 438 239	5 517
SA	Honeymoon Gould's Dam	123 88	200
Queensland	Ben Lomond Maureen Valhalla	264 198 1 090	1 551

Source Areva, *Submission no. 39*, p. 15.

9.66 Similarly, the NTMC estimated current in-ground uranium reserves in the NT at 300 000 t U_3O_8.[90] This equates to an estimated value of some $12 billion, based on a U_3O_8 spot price as at October 2005 of US$30 per pound. However, Dr Ron Matthews argued that 'there is potential to double or treble that, or perhaps even more.'[91]

9.67 Recalculating the potential revenues based on the current spot price significantly increases the value of the uranium resources. For example, total uranium reserves at Jabiluka in the NT are 163 000 t U_3O_8.[92] At the current spot market price, the in-ground value of these reserves is approximately US$15.4 billion (A$20.6 billion).[93]

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89 Spot price for U_3O_8 at 1 June 2006. Uranium market prices available at <http://www.uxc.com/>. The in-ground value calculation also assumes an exchange rate of US$0.78.

90 NTMC, *Submission no. 51*, p. 5.

91 Dr Ron Matthews (NTMC), *Transcript of Evidence*, 24 October 2005, p. 34.

92 Mr Harry Kenyon-Slaney (ERA), *op. cit.*, p. 49.

93 Calculation based on a spot price of US$43 per pound U_3O_8 and an exchange rate of A$1=US74.5c.

9.68 Summit Resources estimated the in-ground value of it uranium resources near Mt Isa in Queensland at over A$3 billion at prices prevailing in November 2005.[94] Summit argued emphatically that:

> The Commonwealth government, the Queensland state government and the city and people of Mount Isa should not be deprived of the significant economic, environmental and social benefits that new and sustainable uranium mines' processing and export operations will deliver over a significant period of time.[95]

9.69 In terms of the value of uranium resources currently 'locked up' in WA due to mining restrictions, Nova Energy estimated that the total reserves and resources in key, known uranium deposits in the state is over 190 000 t U_3O_8.[96] At the current spot market price, the in-ground value of these reserves and resources is approximately US$18 billion (A$24 billion).

9.70 It was estimated that, based on a long-term export sales price for U_3O_8 of US$25 per pound, WA deposits would generate sales revenue of US$1.2 billion per year (A$1.6 billion). Moreover, Nova Energy estimated that a further A$1.5 billion would be added annually throughout the state and the nation due to multiplier effects. Assuming the equivalent royalty to production ratio for key deposits in WA as exist for the Ranger mine in the NT, would result in royalties of A$42 million per year.[97]

9.71 Summit Resources estimated that the total in-ground value of known uranium resources unable to be produced nationwide due to mining restrictions is $32 billion, based on November 2005 prices.[98] Again, given the substantial increase in uranium price in the months since then, this figure is likely to significantly underestimate the in-situ value of the resource.

9.72 MCA argued that restrictions on resource development now involve a higher opportunity cost because the price of uranium has trebled since 2003.

Other countries will supply if Australia chooses not to

9.73 A number of submitters suggested that Australia's willingness to export uranium has negligible impact on international nuclear programs, as Australian uranium could easily be replaced by supplies from other

94 Mr Alan Eggers, *op. cit.*, p. 5. This figure is likely to underestimate the value of the resource as the spot price is now considerably higher.

95 *ibid.*, p. 7.

96 Nova Energy Ltd, *op. cit.*, pp. 11–12.

97 *ibid.*, p. 12–13.

98 Summit Resources Ltd, *Exhibit no. 77*, *op. cit.*, p. 18.

countries.[99] Compass Resources, for example, argued that Australian uranium would be of strategic importance if it is developed, but that if development is constrained, 'marginally higher cost overseas resources will meet the demand.'[100]

9.74 Compass Resources noted that while expanding Australia's uranium exports offers economic benefits to Australia and benefits to the world in terms of safeguarded uranium mined in a best practice manner, other countries will supply if Australia fails to do so:

> I believe, however, that it would be a mistake to think that failure to meet the supply of uranium from Australian sources would somehow disrupt the growth of the nuclear power industry. Uranium is, after all, not a scarce or rare commodity, and, in the absence of Australian production, alternative supplies will make their way onto the market from countries well endowed with uranium resources, such as Canada, south-west Africa, west Africa and former Soviet republics, such as Kazakhstan. Logic would seem to argue that Australia, with its strong regulatory environmental position for mining operations and the adherence to the Nuclear Non-Proliferation Treaty, would be encouraging new uranium operations to meet the increased demand. In that way, we believe that Australia has an opportunity to exert world's best practice on mining operations and will play an important role in monitoring uranium through the nuclear fuel cycle.[101]

9.75 Similarly, Mr Keith Alder, formerly the General Manager of the Australian Atomic Energy Commission, argued that the significance of Australia's uranium resources in the global context was negligible:

> … because if we decided to leave it in the ground it would not make any difference at all … to the development of nuclear power anywhere; there is plenty of other uranium … the Canadians would continue to laugh all the way to the bank because they have far less uranium than we do but they export far more than we do.[102]

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99 See for example: Compass Resources, *op. cit.*, pp. 2, 4; Mr Keith Alder, *Submission no. 7*, p. 1; R Broinowski, *Fact or fission: the truth about Australia's nuclear ambitions*, Scribe Publications, Melbourne, 2003, p. 242.

100 Compass Resources, *op. cit.*, p. 2.

101 Dr Malcolm Humphreys (Compass Resources NL), *Transcript of Evidence*, 16 September 2005, p. 61

102 Mr Keith Alder, *Transcript of Evidence*, 16 September 2005, p. 81. See also: Mr Alan Layton (AMEC), *Transcript of Evidence*, 23 September 2005, pp. 21–22; Mr Alistair Stephens (Arafura Resources NL), *Transcript of Evidence*, 23 September 2005, p. 57.

9.76 The UIC concurred, noting that:

> In a strategic sense, were Australia to withhold its supply of uranium, it is becoming increasingly undeniable and inevitable that those countries needing it will seek it from elsewhere, since it is a low-cost fuel for capital intensive plants.[103]

9.77 The ANF argued that if Australia were to cease exporting uranium the world's nuclear programs would continue:

> We believe that world nuclear programs would continue via an early introduction of breeder reactors, so nothing else would change—except that this country would miss out on a considerable export income and would probably lose influence in world nuclear affairs.[104]

9.78 The ANF argued that, instead, 'Australian uranium exports should be governed primarily by market forces, but consistent with non-proliferation constraints.'[105]

Australia's place in the international fuel cycle

9.79 A number of submitters emphasised Australia's role in establishing a safe, international nuclear energy industry.[106] Their submissions suggested that, by virtue of its significant uranium reserves and growing global demand, Australia is in a position to impose strict conditions on the sale of uranium. Such conditions include comprehensive occupational health and safety and environmental regulations, as well as precautions for the safe use of uranium.[107] The UIC argued that:

> … with the extent of the world's uranium resources it controls, Australia is uniquely placed to exercise even greater international influence to maintain the safety and security of the nuclear fuel cycle.[108]

9.80 The Director General of ASNO, Mr John Carlson, argued that because Australia possesses some 30 per cent of the world's uranium resources recoverable at medium-level cost and is a major exporter means that Australia occupies a significant place in the international fuel cycle and is therefore well placed to pursue non-proliferation objectives:

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103 Mr Ian Hore-Lacy, *op. cit.*, p. 89.

104 Mr James Brough (ANF), *Transcript of Evidence*, 16 September 2005, p. 43.

105 *ibid.*

106 See for example: Compass Resources NL, *op. cit.*, p. 4; UIC, *op. cit.*, p. 11; Nova Energy Ltd, *op. cit.*, pp. ii, 25.

107 *ibid.*

108 UIC, *op. cit.*, p. 11.

> … Australia has a major place in the international fuel cycle. It is a place which has given us very strong standing to pursue non-proliferation objectives. We are a permanent member of the IAEA board of governors. We are very active in the development of non-proliferation mechanisms. We are particularly active in the development of IAEA safeguards. I have a personal appointment as the chairman of the international advisory group that advises the IAEA in the development of safeguards and making safeguards more effective. We have substantial influence through our position as a major uranium exporter.[109]

9.81 Nova Energy stated that Australian uranium is produced within a demanding regulatory regime and is exported under stringent safeguards, enabling the IAEA to track the material throughout its entire life cycle.[110] This, it suggested, was in contrast with conditions placed upon supplies of uranium from developing countries in Asia and Africa.[111] Nova Energy argued that 'the greater the percentage of uranium produced in Australia, the greater the degree of control on its usage.'[112]

9.82 However, Mr Keith Alder noted the prominent position in international nuclear policy that Australia enjoyed in the past, and contrasted this with the minor role it now plays.[113] Mr Alder argued that this transformation was due to Australia losing its 'former expertise relating to power reactors and the nuclear fuel cycle … as a result of changes in Government policy' and observed that 'Australia's only claim to importance in nuclear matters now arises from possession of major uranium resources'.[114]

9.83 A number of submitters argued that it is not appropriate for Australia to export uranium to North Asia, given the geopolitical tensions in that region.[115] Indeed, People for Nuclear Disarmament opposed such exports of uranium, claiming that 'North Asia is a nuclear disaster waiting to happen.'[116]

9.84 Friends of the Earth (FOE) expressed concern about stockpiles of Australian-obligated nuclear material in Japan potentially being diverted

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109 Mr John Carlson (ASNO), *op. cit.*, p. 17.

110 Nova Energy Ltd, *op. cit.*, p. 9.

111 *ibid.*

112 *ibid.*

113 Mr Keith Alder, *Submission no. 7*, p. 1.

114 *ibid.*

115 See for example: People for Nuclear Disarmament NSW Inc.(PND), *Submission no. 45*, p. 9; FOE, *Submission no. 52*, p. 22; MAPW, *Submission no. 30*, p. 4; Professor Richard Broinowski, *Submission no. 72*; p. 3.

116 PFND, *op. cit.*, p. 9.

to a systematic nuclear weapons program.[117] Even in the absence of such a program, FOE suggested that these stockpiles exacerbate tensions in the region.[118] It argued that:

> While the construction of nuclear weapons by Japan is an unlikely development, it cannot be discounted and the assessment could change quickly, for example in the event of a North Korean nuclear test … That latent potential is an ongoing source of tension in north-east Asia — it provides both an incentive and an excuse for countries such as North Korea, South Korea and Taiwan to pursue nuclear weapons programs or to steer ostensibly civil nuclear programs in such a way as to reduce the lead-time for weapons production …[119]

9.85 The Medical Association for the Prevention of War (MAPW) contended that any expansion of the Australian uranium industry was 'indefensible', arguing that:

> Any activity which has significant potential to increase the number of nuclear weapons, the number of countries or other entities possessing them, and/or the possibilities for their use, or lowers the threshold for their use, therefore magnifies what is already the greatest immediate risk to human health and survival.[120]

Conclusions

9.86 Uranium is Australia's second largest energy export in thermal terms, which is of great importance given predictions for an increase in energy demand over the coming decades, particularly in developing countries.

9.87 The Committee concludes that nuclear power represents a significant means of addressing the global energy imbalance. It is an important component of the global energy mix, which can provide developing countries with access to the energy required to fuel their industrialisation and particularly their electricity requirements.

9.88 Uranium production currently generates considerable economic benefits and has the potential to make such contributions in states that currently prohibit uranium mining. In recognising the economic benefits of the industry, the Committee is conscious that failure to permit the

117 FOE, *op. cit.*, p. 22. See also: *ibid.*

118 FOE, *loc. cit.*

119 FOE, *op. cit.*, p. 23–4.

120 MAPW, *op. cit.*, p. 4.

development of the industry has corresponding costs. Such costs include loss of the industry's current and potential contribution to the national and state economies, regional development, services and employment in Aboriginal communities and further promotion of Australia's role in the international nuclear community. As pointed out by Jindalee Resources, the cost to Australia of limiting the development of the uranium industry is:

> … the loss of uranium exploration investment and expenditure, regional development and employment opportunities, royalties and tax receipts, both State and Federal, export income and contributions to the balance of payments.[121]

Impediments to the uranium industry are discussed in greater detail in chapter 11 of this report.

9.89 The Committee notes that while precise estimates of the value of undeveloped uranium resources varies, one conservative estimate suggests that the locked up uranium in Australia could earn revenues in excess of A$32 billion (at prices prevailing in November 2005). Sales of uranium from WA alone could generate revenues of A$1.6 billion per year.

9.90 In summary, the Committee concurs with the view expressed by the UIC, which argued that Australia's uranium resources provide an opportunity, 'reflecting a happy coincidence of national self-interest and environmental altruism.'[122]

9.91 It was submitted that exports of uranium into North and East Asia may raise broader geopolitical issues, such as tensions between China, Japan, Taiwan and the Koreas. The Committee does not agree, however, that increased exports of uranium to these countries will necessarily or appreciably add to any regional tensions.

9.92 Notwithstanding the potential benefits, the Committee was reminded in evidence of an observation made by the Slatyer report 22 years ago, that further expansion of the nuclear power industry will not be dependent on Australian uranium and will proceed irrespective of whether or not Australia supplies uranium.[123] If Australia fails to supply then marginally higher cost overseas resources will be supplied to meet global demand, and these resources may not be provided to the market with the same safeguards and other regulatory requirements imposed on Australian

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121 Jindalee Resources Ltd, *loc. cit.*

122 Mr Ian Hore-Lacy, *op. cit.*, p. 90.

123 ASTEC, *loc. cit.*

exports. However, Australia can contribute to international energy security by being a reliable and stable supplier of uranium.

9.93 In view of the strategic importance of Australia's uranium resources, the potential benefits from the further development of these resources, and following consideration of the fuel cycle risks summarised in the previous four chapters, the Committee concludes that development of new uranium deposits should be permitted and encouraged. In the following chapter the Committee addresses the regulatory arrangements that govern the industry in Australia.

10

Uranium industry regulation and impacts on Aboriginal communities

Given this natural endowment Australia should be the world leader in the production of uranium. However Australia's current regulatory environment dissuades investment in uranium exploration, favours the entrenched position of three existing producers and leaves limited opportunity for the development of other mines by new entrants. This environment is clearly anti-competitive and has sterilised the majority of Australia's uranium deposits. It is in the National Interest that this environment is changed.[1]

1 Jindalee Resources Ltd, *Submission no. 31*, p. 1.

Key messages —

- **State and territory governments are largely responsible for the day-to-day regulation of uranium mining and associated activities. However, oversight of uranium mining is shared between the Australian Government and the governments of the Northern Territory and South Australia.**
- **Industry is generally supportive of state and territory governments regulating uranium mining, and is confident that the current regulatory regime is sufficiently stringent. Industry is concerned, however, with some of the complexity involved and perceived reporting regulations that exceed those of other minerals industries.**
- **Criticisms of perceived failings of the current regulatory regime by those opposed to uranium mining generally relate to the adequacy of environmental protection from the impacts of uranium mining, the performance of the Office of the Supervising Scientist (OSS) in the Alligator Rivers Region (ARR) of the Northern Territory, and alleged conflicts of interest within state and territory regulatory agencies.**
- **The efficacy of the regulatory regime for uranium mining in the ARR is confirmed by the fact that there has been no harm to the Kakadu National Park as a result of the mining operations at Ranger.**
- **Uranium mining regulation in the ARR has, however, evolved into what appears to be an unduly complex regime. The regulatory regime in the NT should be reviewed with a view to consolidation and simplification.**
- **Environmental requirements attached to the Ranger mining lease set clear regulations as to what must be achieved for the mine's eventual rehabilitation. This includes that the mine site needs to be rehabilitated to a standard that will allow its incorporation into the Kakadu National Park. Energy Resources of Australia (ERA), the owners of Ranger, are now making financial allowance to fund the eventual mine closure and rehabilitation. The environmental bond paid by the company and held by government currently stands at $63 million.**
- **The number of incidents reported at Ranger is not indicative of poor performance but of a highly stringent reporting regime, which has resulted in the reporting of incidents that would be considered to be below the threshold level at other mining operations.**

- **The Northern Land Council (NLC) stated that it was no more concerned about the environmental impacts of uranium mining than it was about any other mining that takes place. Indeed, the NLC expressed more concern about the impacts of mining to extract gold.**
- **The Committee notes that while ERA has announced that there will be no further development at Jabiluka without the formal support of the Traditional Owners, in 2000 the World Heritage Committee concluded that the currently approved proposal for the mine and mill at Jabiluka does *not* threaten the health of people or the biological and ecological systems of Kakadu National Park.**
- **Deficient regulation and poor mining practices in past decades have led to ongoing rehabilitation problems at former uranium mine sites in the ARR and elsewhere. Further funding should be provided to ensure that these sites are fully rehabilitated.**
- **While there are a number of impediments to increasing Aboriginal engagement in uranium mining, industry, governments and Indigenous communities themselves should seek to emulate the examples of mining operations, both in Australia and abroad, that have succeeded in achieving employment, business and training benefits for Indigenous communities.**

Introduction

10.1 This chapter, which is divided into four sections, examines concerns about, and potential solutions to, perceived shortcomings of the current regulatory regime.

10.2 The chapter commences with a description of the current regulatory environment, focussing on the Australian Government's involvement. It examines the responsibilities of Australian Government agencies and outlines the legislative bases of their roles.

10.3 The second section details the industry's assessment of the current regulatory regime governing uranium mining in Australia. Industry's views of the adequacy of the current framework, along with their concerns about regulatory consistency and efficiency, are summarised.

10.4 The third section assesses criticisms of the regulatory environment, which broadly go to the perceived inadequacies of the regulations in providing sufficient protection from the alleged harmful impacts of uranium mining on the environment. This section also addresses suggestions in relation to the activities of regulatory authorities and arrangements.

10.5 Finally, this chapter examines consultation with Traditional Owners and the social impacts of uranium mining on Aboriginal communities. This section focuses particularly on: social impact monitoring; the processes for engaging and consulting with Aboriginal communities; opportunities for Aboriginal employment and training; and the *Aboriginal Land Rights Act*.

Overview of current regulatory arrangements

10.6 Mining in Australia is largely conducted under state and territory legislation. In practice however, oversight of uranium mining is a shared responsibility between the Australian Government and the governments of the Northern Territory (for the Ranger and Jabiluka mines) and South Australia (for the Olympic Dam, Beverley and Honeymoon mines).

10.7 General Commonwealth power in uranium mining derives from the external affairs power under the Constitution (section 51 (xxix)). This constitutional power is manifested in an export control regime. Uranium is only mined in Australia for export and hence Commonwealth power is especially significant.

10.8 A second foundation of the Commonwealth's role is its special position in the Northern Territory (NT). Although self-government was granted to the Territory in 1978, the Commonwealth retained control and ownership of uranium. The Ranger mineral leases were granted under the *Atomic Energy Act 1953*, although the mineral leases for the subsequent Jabiluka uranium prospects were issued under NT mining legislation.

10.9 Whilst the Commonwealth retains strong powers through its export permit processes, without which uranium mines would have no commercial viability, day-to-day administration of the mines is regulated by the state and territory governments. The Commonwealth is involved in the initial environmental impact assessment process and in the granting of an export licence for the uranium. The regulation of uranium mining operations, including environmental matters, the health of workers and the safety of the mine operation, is principally the responsibility of the relevant state and territory governments.

10.10 Regulation of mines in the NT is the responsibility of the NT Department of Primary Industry, Fisheries and Mines (DPIFM), with the Commonwealth Office of the Supervising Scientist (OSS) having a monitoring, research and supervisory role over uranium mining activities in the Alligator Rivers Region (ARR).

10.11 In South Australia (SA), day-to-day management of uranium mining is the responsibility of the Department of Primary Industries and Resources

(PIRSA), with regulation of radiation safety aspects of mines being the responsibility of the Environment Protection Authority.

10.12 In addition to its special position in relation to uranium in the NT and environmental assessment and approval, the Australian Government also has responsibility for:

- ensuring the physical security of nuclear materials within Australia;
- approval of exports of radioactive materials, including uranium; and
- implementation of safeguards agreements and tracking of Australian Obligated Nuclear Material internationally.

These matters were addressed in previous chapters.

10.13 The Committee notes that a number of other reports and inquiries, at both state and federal level, have examined aspects of uranium industry regulation. These have included, among others:

- *Uranium Mining and Milling in Australia*—Senate Uranium Mining and Milling Select Committee;[2]
- *Jabiluka: The Undermining of Process – Inquiry into the Jabiluka Uranium Mine Project*—Senate Environment, Communications, Information Technology and the Arts References Committee;[3]
- *Regulating the Ranger, Jabiluka, Beverley and Honeymoon uranium mines*—Senate Environment, Communications, Information Technology and the Arts References Committee;[4]
- Independent Review of Reporting Procedures for the SA Uranium Mining Industry—Hedley Bachmann, for the SA Government;[5] and
- *Review of Environmental Impacts of the Acid In-situ Leach Uranium Mining Process*—Commonwealth Scientific and Industrial Research Organisation (CSIRO), for the SA Government.[6]

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2 Senate Uranium Mining and Milling Select Committee, *Uranium Mining and Milling in Australia*, Parliament of Australia, Canberra, 1997, viewed 17 August 2006, <http://www.aph.gov.au/Senate/committee/uranium_ctte/report/contents.htm>

3 Senate Environment, Communications, Information Technology and the Arts References Committee (SECITARC), *Jabiluka: The Undermining of Process – Inquiry into the Jabiluka Uranium Mine Project*, Parliament of Australia, Canberra, 1999, viewed 17 August 2006, <http://www.aph.gov.au/Senate/committee/ecita_ctte/completed_inquiries/1999-02/jabiluka/report/contents.htm>.

4 SECITARC, *Regulating the Ranger, Jabiluka, Beverley and Honeymoon uranium mines*, Parliament of Australia, Canberra, 2003, viewed 17 August 2006, <http://www.aph.gov.au/Senate/committee/ecita_ctte/completed_inquiries/2002-04/uranium/report/index.htm>.

5 H Bachmann, *Report of the Independent Review of Reporting Procedures for the SA Uranium Mining Industry*, 2002, viewed 18 August 2006, <http://www.heathgateresources.com.au/contentmine.jsp?xcid=62>.

The Committee also notes the work of the Uranium Industry Framework, which is currently developing a uranium industry action plan.

10.14 In view of the extensive treatment that uranium industry regulation has received to date, the Committee does not propose to present a detailed examination of regulatory issues here. The Committee's attention has been drawn specifically to the regulation of the environmental impacts of uranium mining and this chapter largely reflects that.

10.15 The following overview of the current regulatory environment draws on the Senate Environment, Communications, Information Technology and the Arts References Committee (SECITARC) report, *Regulating the Ranger, Jabiluka, Beverley and Honeymoon uranium mines*, and the Uranium Information Centre's (UIC's) paper, *Regulation of Australian Uranium Mining*.[7]

Commonwealth statutes regulating uranium

10.16 The Commonwealth's involvement in the regulation of uranium derives from eight key statutes:

- *Atomic Energy Act 1953*—provides for the authorisation of uranium mining on any land in the Ranger Project Area in the NT. The Australian Atomic Energy Commission (AAEC) was set up by Section 8 of the Act, and its functions set out in Section 17. The AAEC was replaced in 1987 by the Australian Nuclear Science and Technology Organisation (ANSTO), established by the *Australian Nuclear Science and Technology Commission Act 1987*.
- *Environment Protection and Biodiversity Conservation Act 1999* ('the EPBC Act')—the principal legislative scheme for the mining, use and disposal of uranium. The key purpose of the Act is to clarify the matter of Commonwealth environmental jurisdiction, based on six matters of national environmental significance, one of which is 'nuclear actions' (defined to include 'mining or milling uranium ore'). Where a nuclear action has, will have, or is likely to have, a significant impact on the environment, approval must be sought from the Australian Government Environment Minister. Before a project can proceed, the proposed action must undergo a Commonwealth environmental assessment and approval process, although these can be undertaken

6 G Taylor et. al., *Review of Environmental Impacts of the Acid In-situ Leach Uranium Mining Process*, CSIRO, Melbourne, 2004, p. 1, viewed 12 July 2005, <http://www.environment.sa.gov.au/epa/pdfs/isl_review.pdf>

7 SECITARC, *Regulating the Ranger, Jabiluka, Beverley and Honeymoon uranium mines*, *op. cit.*, pp. 1–20; UIC, *Regulation of Australian Uranium Mining*, UIC, Melbourne, 2006, viewed 17 August 2006, <http://www.uic.com.au/mineregulation.htm>.

jointly by the Commonwealth and the state or territory governments when required under both Commonwealth and state or territory law.

- *Nuclear Non-Proliferation (Safeguards) Act 1987*—has the objective of ensuring the physical security of nuclear materials within Australia. Underlying this legislation, possession of nuclear material requires a permit and approval from the Australian Safeguards and Non-Proliferation Office (ASNO).
- *Environment Protection (Alligator Rivers Region) Act 1978* (EPARR Act)—introduced by the Commonwealth following the report of the 1976 Ranger Uranium Environmental Inquiry (described in a following section), which highlighted the need for strong protection measures for the region's environment in relation to uranium mining activities. The Act is concerned with the administrative arrangements for the Australian Government's oversight of uranium mining operations in the ARR in the NT, which encompasses the Ranger and Jabiluka mine sites. The legislation established the OSS, which operates within the Department of the Environment and Heritage (DEH) and incorporates the Environmental Research Institute of the Supervising Scientist (ERISS). The OSS is responsible for the supervision, monitoring and audit of uranium mines in the ARR as well as research into the possible impact of uranium mining on the environment of the region.

  In 1993–94, the Act was amended to provide for the establishment of the following consultative bodies:

  ⇒ ARR Advisory Committee (ARRAC), which facilitates communication between community, government and industry stakeholders on environmental issues associated with uranium mining in the ARR; and

  ⇒ ARR Technical Committee (ARRTC), which performs reviews of the research and monitoring programs relevant to uranium mines in the ARR.

  A Mine Site Technical Committee (MSTC) was also established. The OSS was initially incorporated within the then Department of Environment, Sport and Territories. Following leaks of tailings water at the Ranger mine during the 1999–2000 wet season, the role of the Supervising Scientist Division (SSD) was expanded to focus on environmental monitoring, on the basis that the OSS should collect its own data rather than rely solely on data gathered by the mining operator, Energy Resources of Australia (ERA), and DPIFM.
- *Australian Radiation Protection and Nuclear Safety Act 1998*—regulates the transportation of uranium and its by-products. The object of the Act is to '[p]rotect the health and safety of people, and to protect the

environment, from the harmful effects of radiation' (Section 3). The Act also established the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), which is the statutory body responsible for the administration of the Act.

- *Aboriginal Land Rights (Northern Territory) Act 1976*—the Commonwealth gains additional jurisdiction in the NT through the operation of this Act. The Act establishes the Northern Land Council (NLC) as a statutory authority to represent the interests of Aboriginal Traditional Owners. Both Ranger and the proposed Jabiluka mine are located within the NLC's area of jurisdiction, and both are on land which is traditionally owned by the Mirrar–Gundjeihmi people. The Australian Government has recently proposed changes to the Act.
- *Customs (Prohibited Exports) Regulations 1958* under the *Customs Act 1901*—under regulation 11, an export licence is necessary for the export of radioactive material, including refined uranium, plutonium and thorium. Amendments to the regulations were made in August 2000 to strengthen Commonwealth control over uranium exports by enabling export permissions (or licences) for uranium to be granted subject to conditions. Under the regulations, the Australian Government Minister for Industry, Tourism and Resources is provided with a mechanism by which to place legally binding conditions, including mine-site environmental conditions, on the export of uranium.
- *Nuclear Safeguards (Producers of Uranium Ore Concentrates) Charge Act 1993*—establishes a Uranium Producers Charge, through which the Commonwealth recoups approximately 40 per cent of ASNO's annual costs. The fee is charged on each kilogram of production and in October 2003 was set at 6.0453 cents per kilogram of contained uranium, up to a maximum of $500 000 for each producer.

10.17 In addition to the operation of these Acts, ARPANSA publishes codes of practice for uranium mining. These are detailed in the descriptions of the key Commonwealth regulatory agencies which follow.

Commonwealth regulatory agencies

10.18 The Australian Government's involvement in the regulation of uranium mining and nuclear matters is conducted principally through three portfolios: Environment and Heritage; Industry, Tourism and Resources; and Foreign Affairs and Trade, notably through ASNO. In addition, the Health and Ageing portfolio, through ARPANSA, has specific roles. A summary of each authority's involvement in uranium regulation follows.

Department of Industry, Tourism and Resources

10.19 The Department of Industry, Tourism and Resources (DITR) develops policy and administers legislation relating to Australia's resources and energy industries.[8] DITR also plays an important role in formulating the national response to climate change issues. The Resources area is responsible for providing policy and legislative advice and administrative support to the Government on the resources sector of the economy, which includes uranium.

10.20 The Uranium Industry section is located within the Resources Development Branch and Resources Division of DITR. The goal of the section is to encourage the sustainable development and growth of Australia's uranium mining industry. It focuses on ways to encourage and manage the development and operation of Australia's uranium industry by:

- reducing impediments to the development and operation of uranium projects;
- granting export permits for items listed under Schedule 7 of the *Customs (Prohibited Exports) Regulations 1958* (the Regulations); and
- seeking to ensure a more consistent and accountable regulatory regime for uranium mining that meets environmental objectives.[9]

10.21 The section works closely with agencies such as ASNO, the Department of Foreign Affairs and Trade and the Australian Customs Service to ensure procedures are followed in the exportation of uranium, thorium and other controlled ores listed under Schedule 7 of the Regulations.

10.22 DITR monitors and supports industry applications for environmental approval under the EPBC Act. As noted above, the Act legislates the need for environmental approval for new projects and/or extensions of existing projects that affect matters of national environmental significance. The Act requires that relevant Commonwealth Ministers are consulted when approval is sought for proposed projects within their area of responsibility. In addition, DITR is required under the Act to report annually on Australia's environmental performance and contribution to ecologically sustainable development.[10]

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8 See: Uranium Industry Section at DITR, *ITR Homepage*, Australian Government, Canberra, viewed 17 August 2006, <http://www.industry.gov.au>.

9 *ibid.*

10 *ibid.*

Department of the Environment and Heritage

10.23 DEH advises the Commonwealth Government on policies and programs for the protection and conservation of the environment, including both natural and cultural heritage. It has four key responsibilities in relation to uranium mining:

> … firstly, the assessment and approval of proposals for new uranium mines or the expansion of an existing uranium mine under the Environment Protection and Biodiversity Conservation Act 1999, known as the EPBC Act; secondly, the Supervising Scientist's monitoring, research and supervisory role in relation to uranium mining activities in the Alligator Rivers region of the Northern Territory; thirdly, the management of Commonwealth reserves by the Director of National Parks, including Kakadu National Park, which surrounds the Ranger and Jabiluka sites; and, fourthly, through the delivery of the Australian government's climate change strategy, a key interest in energy issues, including nuclear fuels.[11]

10.24 The Department administers environmental laws, and is responsible for Australia's participation in a number of international environmental agreements. DEH explained that the EPBC Act is 'the most fundamental reform of Commonwealth environmental laws since the first environmental statutes were enacted in the early 1970s,' allowing streamlined environmental assessment and approval processes.[12] Importantly, the Act also 'ensure[s] that all future uranium mines are subject to a stringent and comprehensive environmental assessment process.'[13]

10.25 With regard to the uranium mining industry in SA, DEH's role as an environmental regulator is demonstrated through the approvals process and in the Department's authority to set strict conditions governing the operating procedures of the mines. In the NT, the OSS supervises the management of the uranium mining industry and conduct research into the industry's impact on the ARR environment.

10.26 As described in the overview of relevant legislation in the preceding section, the SSD is responsible for environmental oversight of uranium mining activities in the ARR. The primary role of the SSD is to ensure, through research, assessment and the provision of technical advice, that the environment of the ARR is protected from the effects of uranium

11 Mr David Borthwick (DEH), *Transcript of Evidence*, 10 October 2005, p. 2. See also: DEH, *Submission no. 55*, p. 5.

12 DEH, *ibid.*, p. 24.

13 *ibid.*

mining to the standard required by the Australian Government. The supervisory functions are carried out by the OSS, and the research functions of the SSD are performed by ERISS.

10.27 The world heritage values of the Kakadu and concerns of the Traditional Owners were said to demand a strict regulatory regime. The need for strict regulation also reflects that uranium is a radioactive element and hence measures must have a high degree of reliability for unusually long periods of time.[14]

10.28 DEH argued that this supervisory role is 'demonstrably effective' and that 'the regime is one of the most rigorous regimes currently in place for any mining operation anywhere in the world.'[15]

Australian Safeguards and Non-Proliferation Office

10.29 The principal focus of ASNO is on international and domestic action against the proliferation of weapons of mass destruction (WMD)—nuclear, chemical and biological—and also radiological weapons. Thus, the Office's work relates directly to international and national security. In particular, ASNO works to strengthen the operation of treaty verification regimes and their supporting technical methods. In addition, it performs domestic regulatory functions, ensuring that Australia complies with relevant treaty commitments, and that the public is protected through appropriate security standards for WMD-related materials.[16]

10.30 ASNO's responsibilities cover nuclear materials—uranium, thorium and plutonium—not general radioactive materials as such. ASNO's legislation applies to all persons or organisations in Australian jurisdiction having relevant materials, items or technology. Principally this applies to ANSTO, as Australia's only nuclear operator, but also covers a diverse range of other entities including uranium mines and associated transport and storage operations, private sector laboratories, educational institutions, and patent attorneys. ASNO's activities are based on a number of constitutional heads of power, especially the external affairs power.

10.31 Among his principal functions, the Director General of ASNO (currently Mr John Carlson) is responsible for ensuring the effective operation of the *Nuclear Non-Proliferation (Safeguards) Act 1987*, the *Comprehensive Nuclear Test-Ban Treaty Act 1998* and fulfilment of Australia's obligations under the treaties these Acts implement.

10.32 ASNO's three key interests in the regulation of uranium mines are:

14 *ibid.*

15 *ibid.*, p. 25.

16 ASNO, *ASNO website*, Australian Government, Canberra, viewed 17 August 2006, <http://www.asno.dfat.gov.au>.

- ensuring that any uranium produced is properly accounted for;
- ensuring the effective control of uranium, with access to uranium granted only to authorised persons, for authorised purposes; and
- ensuring that exports of uranium comply with the terms of Australia's bilateral safeguards agreements.[17]

10.33 ASNO ensures that producers of uranium maintain accountancy records, including records of production, export licensing and shipping documentation. This contributes to ensuring that any uranium produced in Australia is properly accounted for.[18]

10.34 ASNO meets its obligation to effectively control uranium by requiring appropriate levels of physical protection at mine sites and storage areas, and by liaising with its counterparts in countries through which AONM will transit, alerting them to the need to protect such material in their jurisdiction.[19]

10.35 In addition to ensuring compliance with bilateral safeguards agreements, ASNO ensures that Australia's international obligations are met under the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), Australia's NPT safeguards agreement with the International Atomic Energy Agency (IAEA), and the *Convention on the Physical Protection of Nuclear Material 1979*.[20]

Australian Radiation Protection and Nuclear Safety Agency

10.36 Established under the *Australian Radiation Protection and Nuclear Safety Act 1998* (ARPANS Act) described above, ARPANSA is responsible for protecting the safety and health of people and the environment from the harmful effects of radiation.[21]

10.37 ARPANSA's functions are to:

- promote the uniformity of radiation protection and nuclear safety policy and practices across the Commonwealth, states and territories;
- provide advice to Government and the community on radiation protection, nuclear safety (reactors and visits by nuclear-powered warships) and related issues;
- undertake research and provide services in relation to radiation protection, nuclear safety and medical exposures to radiation;

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17 The Hon Alexander Downer MP, Minister for Foreign Affairs, *Submission no. 33*, p. 8.

18 *ibid.*

19 *ibid.*

20 *ibid.*, p. 9.

21 ARPANSA, *Submission no. 32*, pp. 2–3.

- regulating radiation protection and nuclear safety aspects of all Commonwealth entities involved in radiation or nuclear activities and dealings;
- accredit persons with technical expertise for the purposes of the ARPANS Act; and
- monitor compliance with prohibitions related to the regulation of controlled material, controlled apparatus and controlled facilities.[22]

10.38 ARPANSA regulates a wide range of nuclear and radiation facilities and sources, including nuclear installations, waste facilities and radioactive materials. Among its other activities, ARPANSA reviewers assess applications for licences against international best practice in radiation protection and nuclear safety, undertake inspections and take any enforcement actions necessary to ensure compliance with the Act and Regulations. The CEO of ARPANSA (currently Dr John Loy) is required to report annually to the Minister for Health any breach of licence conditions by a licensee.

10.39 ARPANSA publishes the Radiation Protection Series to promote practices that protect human health and the environment from the possible harmful effects of radiation. The Series contains four categories of publication, two of which apply to uranium mining:

- Codes of Practice are prescriptive in style and may be referenced by regulations or conditions of licence. They contain practice-specific requirements that must be satisfied to ensure an acceptable level of safety in dealings involving exposure to radiation.[23] Requirements are expressed in 'must' statements.
- Recommendations provide guidance on fundamental principles for radiation protection. They are written in an explanatory and non-regulatory style and describe the basic concepts and objectives of best international practice.

10.40 The Codes and Recommendations relevant to uranium mining include:

- Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing (2005);
- Code of Practice for the Safe Transport of Radioactive Substances (1982); and
- Recommendations for Limiting Exposure to Ionising Radiation (1995).

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22 *ibid.*

23 ARPANSA, *Exhibit no. 67, Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing.*

10.41 Compliance with the Codes of Practice, or aspects of them, is a requirement of authorisations issued by the NT Government or licences by the SA Government for the mining of uranium.

State government responsibilities

10.42 The day-to-day regulation of uranium mining activities is a responsibility of state and territory governments. State regulations encompass matters including health, safety and the environment, although, as described above, the Australian Government is also involved in the environmental regulation of uranium mining.[24]

10.43 The EPBC Act provides the Minister for the Environment and Heritage with a vehicle to directly issue approval conditions to a proponent of any new or expanded uranium mine. The proposed expansion of Olympic Dam in SA is the first uranium mine proposal to be considered under the EPBC Act.[25]

10.44 Under an agreement between the NT and Australian Governments on the regulation of mining in the Territory, before the NT Minister for Mines and Energy grants or varies an authorisation under Territory legislation the matter must be referred to the Supervising Scientist for comment. The Territory Minister must not act until that comment is received. The Supervising Scientist may refer the matter to the Australian Government Minister for the Environment and Heritage. If the matter is referred, the Territory Minister must act in accordance with the advice of the Australian Government Minister.

10.45 DEH explained that the Supervising Scientist's monitoring, research and supervisory role is separate and independent from the regulatory responsibilities of the Australian Government's industry portfolio and the Territory Government's mines and energy portfolio.[26]

10.46 It was explained that the Environment Minister has a 'considerable range of discretion' as to the conditions he or she can impose on a mining operation, and that these conditions will vary depending on the assessment of the environmental impacts of each specific proposal.[27]

10.47 DEH emphasised the importance of having an independent supervisor for health and environmental aspects of uranium mining, as occurs with the

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24 For an overview of state-level arrangements, see: UIC, *loc. cit.*; and for arrangements in the NT in particular, see: ERA, *Submission no. 46*, pp. 4-9.

25 Mr Gerard Early (DEH), *Transcript of Evidence*, 10 October 2005, p. 3.

26 *ibid*.

27 *ibid*., p. 4.

Supervising Scientist in the ARR and ARPANSA, separated from the industry promotional functions of Government:

> We think it is absolutely fundamentally important to have those regulatory functions at the Commonwealth level separated from the policy promotional functions of public health and that those processes be transparent and open …[28]

10.48 DEH explained that under the EPBC Act, the Minister for the Environment's role will be limited to the approval and assessment process and that the Supervising Scientist's role only applies to the ARR. The monitoring, research and supervisory role of the Supervising Scientist in relation to uranium mining only applies to the ARR in the NT. DEH mooted whether consideration could be given to expanding this role in order to ensure 'independent, arms-length regulatory oversight'.[29] The Committee returns to this matter following a discussion of the OSS.

10.49 As to the adequacy and appropriateness of federal regulation, the Supervising Scientist remarked that the ARR is particularly sensitive because of the overlay of three issues of concern to the public—uranium itself, the iconic nature of the Kakadu National Park, and mining taking place on Aboriginal land. In summary, the Supervising Scientist maintained that 'those three issues come together to make it a highly significant area' and that the regulation is therefore not excessive.[30]

10.50 Mining in the NT is conducted under two principal pieces of Territory legislation—the *Mining Act*, which regulates the issue of exploration licenses and leases, and the *Mining Management Act* which governs the operational aspects of mining in the Territory. Under the *Mining Management Act*, which came into force in 2002, companies are required to operate under a mining management plan, which covers both occupational health and safety and environmental aspects of mining operations. Mining management plans are approved and reviewed annually.[31]

10.51 NT Government officials noted that section 175 of the *Mining Act* requires the Territory Minister to consult with and have regard to the advice of the Commonwealth Minister in relation to most matters under the Act, including the granting of mineral leases. However, the NT Minister 'could grant or reasonably refuse to grant an exploration license.'[32] The new *Mining Management Act* contains similar provisions and requires the

28 *ibid.*, p. 14
29 *ibid.*, pp. 4, 7, 14.
30 Dr Arthur Johnston (Supervising Scientist, DEH), *Transcript of Evidence*, 10 October 2005, p. 4.
31 Mr Richard Jackson (NT Government), *Transcript of Evidence*, 24 October 2005, p. 58.
32 *ibid.*, p. 59.

Territory Minister to consult with the Federal Minister in relation to issuing an authorisation under the Act.

10.52 In relation to the decision of the Australian Government to assume responsibility for the uranium mine approval process, Territory Government officials argued that at the operational level changes are unlikely: 'the Northern Territory government is keen to continue to look after the day-to-day regulation of uranium mining and that is something that is supported by the Commonwealth.'[33] Territory officials also stated that they 'work well with the Commonwealth in relation to Ranger … if there were another [mine] in the equation we would work just as well.'[34]

Industry's assessment of existing regulation

10.53 Uranium producers were supportive of state and territory governments regulating uranium mining and associated activities, given their experience and history in these areas.[35] Compass Resources observed that state governments regulate mineral developments competently: 'They are closest to the action, and that tends to result in more streamlined yet issue-focussed approval processes.'[36]

10.54 Some junior companies and other companies not presently mining uranium in Australia acknowledged their limited experience with the full scope of the regulatory framework but were positive about those aspects that they had so far encountered. Deep Yellow, for example, was very positive about its experience with the regulatory framework in the NT. Indeed, the regulatory environment was credited with being:

> … a strong educational tool to companies regarding their obligations to the various stakeholders in the process including community, government, environment and traditional landowners.[37]

10.55 Compass Resources noted that, notwithstanding the Federal intervention in the NT which it welcomed, ideally, the Territory Government would continue to regulate mining.[38] Similarly, in terms of the day-to-day

33 *ibid.*

34 *ibid.*

35 UIC, *Submission no. 12*, p. 16.

36 Dr Malcolm Humphreys (Compass Resources NL), *Transcript of Evidence*, 16 September 2005, p. 62. See also: Mr Mark Chalmers (Heathgate Resources Pty Ltd), *Transcript of Evidence*, 19 August 2005, p. 96.

37 Deep Yellow Ltd, *Submission no. 16*, p. 2. See also: Cameco Corporation, Submission no. 43, p. 1.

38 Dr Malcolm Humphreys, *loc. cit.*

regulation of the uranium industry in the NT, the Northern Territory Minerals Council (NTMC):

> … continues to support the Mines Division of the Department of Primary Industries, Fisheries and Mines, as the prime regulator on a day-to-day basis, based on agreed arrangements between the Northern Territory and Commonwealth governments.[39]

10.56 The SA government was applauded for its progress with dovetailing the regulatory requirements of the state and federal systems. Paladin Resources observed that:

> South Australia has developed a regulatory regime which seems to have married the requirements of the State and the Commonwealth across the wide range of issues affecting uranium mining.[40]

10.57 Further, Heathgate Resources praised SA regulatory bodies for being:

> … extremely supportive in both the obtaining of approvals to operate and the ongoing regulation of an operating mine, while at the same time ensuring operations are conducted according to all legislative requirements.[41]

Adequacy of the current regulatory regime

10.58 Some submitters argued there is a need for stringent regulations governing uranium exploration, mining and exports, particularly:

> … given the magnitude of environmental and human health damage that can be caused by radiation emanating from their waste materials or leaks from their processes …[42]

10.59 So long as Australia remains a dominant supplier of uranium, it will be incumbent on it 'morally and politically, to play a very strong leadership role in regulating … the industry,' and to make a significant contribution to developing international 'best practice' for the industry.[43]

10.60 Indeed, the Association of Mining and Exploration Companies (AMEC) and the UIC commented on progress Australia had already made in this respect. AMEC stated that 'Australia's radiation safety regulations today

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39 *ibid*.

40 Paladin Resources Ltd, *Submission no. 47*, p. 7.

41 Heathgate Resources Pty Ltd, *Submission no. 49*, p. 3. See also: Mr Cedric Horn (Southern Gold Ltd), *Transcript of Evidence*, 19 August 2005, p. 18.

42 APChem, *Submission no. 38*, p. 7.

43 CFMEU Mining and Energy, *Submission no. 26*, p. 4; Compass Resources NL, *Submission no. 6*, p. 2.

are among the most comprehensive and stringent in the world.'[44] The UIC further observed that:

> The stringency of Australia's approach, ensuring Australian involvement in regulating for the full life of its nuclear material through ASNO, is internationally recognised for the contribution it has made to ensuring such material is not diverted for military purposes.[45]

10.61 Several submitters were confident that the current regulatory regime was sufficiently stringent in ensuring the responsible export of uranium, and adequately protecting the physical environment and citizens' safety.[46] For instance, Heathgate Resources 'support[s] the current high standards of regulatory controls' in Australia.[47] Compass Resources also felt that the current processes for approving and monitoring mining activities have generally performed well.[48]

10.62 Similarly, the Australian Nuclear Association (ANA) stated that environmental and export safeguards for uranium are adequate.[49] It noted that efforts to ensure Australia's uranium is only used for peaceful purposes had resulted in a stringently regulated industry:

> The ANA believes that the uranium mining industry in Australia is adequately controlled by the Commonwealth and state governments with respect to environmental protection and safeguards for the peaceful use of the exported product.[50]

10.63 Nova Energy argued that regulation of uranium mining—from occupational health and safety to export controls and safeguards—is effective:

> We firmly believe that the export licensing regime, the occupational health and safety regime from a mining perspective for the industry through to the export regime around uranium in this country is one of the best in the world and should give us all the confidence that we will only export uranium to where it is used for power generation, and that is well understood and can be

44 AMEC, *Submission no. 20*, p. 4

45 UIC, *op. cit.*, p. 11.

46 See for example: ANA, *Submission no. 19*, p. 4; *ibid.*, p. 16; ERA, *op. cit.*, pp. 5–6; Paladin Resources Ltd, *op. cit.*, p. 2; Nova Energy Ltd, *Submission no. 50*, p. 9.

47 Mr Mark Chalmers, *loc. cit.*

48 Compass Resources NL, *op. cit.*, p. 3.

49 ANA, *loc. cit.*

50 *ibid.*, pp. 3–4.

> tracked and monitored. The regimes exist to do that very effectively in this country.[51]

10.64 Mr Harry Kenyon-Slaney, Chief Executive of ERA, argued that the regulatory regime that governs ERA and its Ranger mine is very comprehensive:

> We currently have five independent bodies who monitor our every move. We have the Alligator Rivers Region Technical Committee, we have the Alligator Rivers Region Advisory Committee, we have a mine site technical committee, we have the Australian Safeguards and Non-Proliferation Office, we have the Northern Territory Government and we have the Supervising Scientist, whose office was set up specially to monitor the environmental impacts that uranium mining has on the surrounding ecosystem. There is an extremely low threshold as to reporting and, as you have probably seen, an enormous amount of information is communicated widely and reported upon whenever anything happens. A spill of a litre of oil in the pit is communicated to the authorities. Personally, I feel that the regulatory environment is comprehensive. Certainly on my watch it is respected and accepted. I am sure that changes for the better could be made and that all the parties continually strive to make those. I certainly do not feel that there is in any way an environment where information is not communicated to stakeholders.[52]

Industry's criticisms of existing regulations

10.65 The industry's central concerns about existing regulations related to: cross-jurisdictional differences, incongruities and the complexity of the regulatory environment in the NT; and perceived excessive regulation of the uranium industry.

10.66 Although ERA 'accept[ed] that the regulatory regime needs to be strict and comprehensive', it acknowledged that the regulations in the NT were complex:

> … history has delivered a complex mix of issues—the Aboriginal Land Rights Act, the Local Government Act and the establishment of the Kakadu National Park—and that requires a complex mix of different laws and regulations.[53]

51 Mr Richard Pearce (Nova Energy Ltd), *Transcript of Evidence*, 23 September 2005, p. 77.

52 Mr Harry Kenyon-Slaney (ERA), *Transcript of Evidence*, 24 October 2005, p. 51. See also: ERA, *Submission no. 46*, p. 5; ERA, *Exhibit no. 76*, *op. cit.*, pp. 6–7.

53 *ibid.*

10.67 Noting the regulatory differences between Ranger and Jabiluka, ERA acknowledged that the existing regulatory environment in the NT was not ideal:

> If we were at the very beginning of developing a uranium mining industry in this country we would probably develop a slightly different regulatory framework. But we are where we are and we have a number of differences between the regulatory environment for Ranger and for Jabiluka.[54]

10.68 ERA submitted that complying with the existing regulations in the NT is costly. Oversight by the OSS and three independent bodies in the ARR is unique and costs the company $10 million in compliance expenses each year.[55]

10.69 The uranium industry claimed that it is subject to regulations that are far more stringent than those imposed on other industries:

> At the moment it would seem that the uranium industry is under much greater scrutiny than other industries, arguably with at least the same, if not greater, occupational health implications … That does not seem to me to be terribly reasonable.[56]

10.70 Existing producers were of the view that the current regime is 'onerous', especially when compared with regulation of other industries, and called for these perceived inequities to be reconsidered. The industry's view is that:

> The requirement for high standards of safety and environmental performance by the uranium mining industry is appropriate, but no more so than for any other industrial activity involving people as workers or neighbours, or having a potential impact on the environment. The current regulatory regime is onerous for the industry, particularly in comparison with industries such as agriculture, forestry, tourism and manufacturing.[57]

10.71 Another submitter suggested that the regulatory environment is 'politically oriented and over zealous. It panders to the green movement and is not based on serious science or logic.'[58]

10.72 The NTMC was also critical of existing regulations preventing the development of the uranium industry:

54 *ibid.*, p. 48.

55 ERA, *Exhibit no. 76*, *What is it really like to operate a large uranium mine in Australia?*, p. 6.

56 Mr Ian Hore-Lacy (UIC), *Transcript of Evidence*, 19 August 2005, p. 91.

57 UIC, *loc. cit.*

58 Name withheld, *Submission no. 25*, p. 1.

> … there is no justification for restricting the development of further uranium mines in the Territory … both the NT and Commonwealth governments need to work together to encourage the search for new deposits and provide the relevant support.[59]

Regulatory reform

10.73 Industry supported improving the regulatory system in order to:

> … ensure the highest possible standards of occupational and public safety and environmental protection, while avoiding duplication and unnecessary administrative burdens and costs.[60]

10.74 What makes uranium unique among minerals is the requirement for Commonwealth review and companies want this to be kept as simple, efficient and timely as possible.[61]

10.75 The uranium industry did not argue that regulation should be softened, but expressed the hope that:

> … as a result of this inquiry, policy at all levels of government will enable uranium mining in Australia to further develop under legislative and regulatory requirements that ensure the highest possible standards of occupational health, public safety, environmental protection and countering weapons proliferation.[62]

10.76 The MCA advocated adoption of a 'minimum effective regulation' approach to structuring the regulatory environment, which it describes as involving:

> … minimum, efficient … and only necessary government regulatory intervention … consistent with meeting, *inter alia*, occupational and public safety and environmental requirements.[63]

10.77 Paladin Resources stated that:

> The only "special treatment" needed is the maintenance of an effective safeguards regime and continuation of best practice standards for occupational health and safety.[64]

10.78 The Committee regrets that, other than one detailed set of regulatory reforms proposed by a group critical of uranium mining, no reform proposals were made by existing producers or juniors. Nonetheless, a

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59 Ms Kezia Purick (NTMC), *Transcript of Evidence*, 24 October 2005, p. 33.

60 *op. cit.*, pp. 4, 16.

61 Compass Resources NL, *loc. cit.*

62 Mr Ian Hore-Lacy, *op. cit.*, p. 89.

63 MCA, *Submission no. 36*, p. 12.

64 Paladin Resources Ltd, *op. cit.*, p. 3.

range of impediments to the industry's development were identified and these are discussed in the following chapter. The following section addresses criticisms of existing regulations, focussing on the alleged environmental impacts of the industry in Australia.

Criticisms of current regulation

10.79 Some 47 submitters were opposed to uranium mining outright and called for the industry's closure. For example, one submitter's view was that: 'To continue mining shows contempt for the human race'.[65]

10.80 Those opposed to uranium mining altogether generally considered that the regulatory arrangements governing the industry were inadequate.[66] A number of submitters provided detailed criticisms of the regulatory arrangements, much of which focussed on the following issues:

- the alleged inadequacy of environmental regulations;
- the role and performance of the Office of the Supervising Scientist; and
- conflicts of interest within agencies required to both promote and regulate uranium mining.

Environmental regulation

10.81 Much of the criticism of the regulatory regime focussed on the alleged paucity of environmental protection provisions. For example, Friends of the Earth (FOE) viewed the environmental impact assessment process as being 'inadequate'.[67]

10.82 Witnesses noted that the Senate Environment Committee found that the industry is characterised by 'under performance and non-compliance' and concluded that the regulations were 'complex, confusing and inadequate'.[68]

10.83 The Australian Conservation Foundation (ACF) also called for the 2003 Senate Environment Committee report to be responded to and its recommendations implemented.[69] Areva, however, argued that some of the Senate Committee's recommendations are 'at odds with an objective

65 Ms Rita Warleigh, *Submission no. 83*, p. 2. See also: Ms Stephanie Riddel, *Submission no. 80*, p. 1.

66 See for example: FOE, *Submission no. 52*, p. 9; Mr Justin Tutty, *Submission no. 41*, p. 7; GAC, *Submission no. 44*, p. 26.

67 FOE, *op. cit.*, p. 10.

68 Mr Dave Sweeney (ACF), *Transcript of Evidence*, 19 August 2005, p. 79.

69 ACF, *Submission no. 48*, p. 25. See also: Mr Justin Tutty, *op. cit.*, p. 9; GAC, *op. cit.*, p. 5.

and balanced assessment of the industry'.[70] For example, Areva cited the Senate Committee's suggestion that in-situ leach mining is an experimental technology as an indication that its conclusions were not necessarily realistic.[71]

10.84 The Gundjeihmi Aboriginal Corporation's (GAC's) concerns about regulation included:

- inconsistency between regulations that govern Ranger and Jabiluka, despite both being on Mirrar land;
- lack of accountability—for example, use of non-statutory agreements to govern most regulation and monitoring;
- outdated provisions;
- inadequacy of the *Aboriginal Land Rights Act* (ALRA), which allegedly prevents the Traditional Owners being directly involved in the management of their land; and
- lack of monitoring of social and cultural impacts (addressed separately below).[72]

10.85 The GAC recommended the overhaul and consolidation of regulations, rather than piecemeal reform.[73] It made six specific recommendations in relation to the regulatory environment, which are summarised below, along with the DEH's response to each:

- Firstly, the GAC recommended that the responsibilities of the Australian Government, in relation to uranium mining in the ARR, be clarified.[74] Such clarification would include affirming the: extent of the Australian Government's ownership of uranium; accountability for uranium mining, including environmental and social impact monitoring; and the environmental impact of uranium mining in the ARR.

  The DEH responded that the 'roles and responsibilities of the Australian Government are already set out under various pieces of legislation' as well as the *Agreement between the Commonwealth of Australia and the Northern Territory of Australia in relation to principles to be applied in the regulation of Uranium Mining in the Northern Territory of*

70 Areva Group, *Submission no. 49*, p. 16.

71 *ibid.*

72 GAC, *op. cit.*, pp. 26–35.

73 *ibid.*, pp. 26–34.

74 *ibid.*, pp. 33–4.

Australia (dated 17 November 2000) ('17 November 2000 Agreement').[75] The DEH considered these arrangements to be appropriate.[76]

- The GAC also advocated clarifying the responsibilities of the NT Government in relation to uranium mining in the ARR, including its responsibility for granting mining leases and authorising and regulating uranium mining.[77]

  The DEH advised that the responsibilities of the NT Government are already clearly set out in the NT *Mining Management Act 2001* and through the 17 November 2000 Agreement.[78]

- The GAC recommended that appropriate Environmental Requirements, and associated enforcement mechanisms, be set out in relation to uranium mining in the ARR.[79]

  The DEH considered that the current Environmental Requirements are appropriate, and noted that the NT Government, in consultation with the Supervising Scientist, is currently developing a related enforcement policy.[80]

- The GAC saw a need to set out the responsibilities of the Supervising Scientist and ERISS, particularly in relation to their relationship with the NT Supervising Authority.[81]

  The DEH explained that the roles and responsibilities of these entities are already described in sections 5 and 24 of the EPARR Act.[82] Furthermore, the cooperative relationship between OSS and ERISS on the one hand, and the NT Government on the other, is detailed in the *Revised Working Arrangements for Co-ordinating the Regulation of the Environmental Aspects of Uranium Mining in the Northern Territory (May 2005)* ('Working Arrangements') and the 17 November 2000 Agreement.[83]

- The GAC also recommended either clearly setting out the functions of ARRAC, ARRTC and the MSTCs, or creating a single entity that would consolidate the functions of these bodies.[84]

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75 DEH, *Submission no. 55.2*, p. 2.
76 *ibid.*
77 GAC, *op. cit.*, p. 34.
78 DEH, *Submission no. 55.2*, *loc. cit.*
79 GAC, *loc. cit.*
80 DEH, *Submission no. 55.2*, *loc. cit.*
81 GAC, *loc. cit.*
82 DEH, *Submission no. 55.2*, p. 3.
83 DEH, *Submission no. 55.2*, *loc. cit.*
84 *loc. cit.*

In relation to the functions of the ARRAC, ARRTC and MSTCs being clearly set out, the DEH stated that the functions of ARRAC and ARRTC are described in section 11 and 16 of the EPARR Act and the functions of the MSTCs are detailed in the Working Arrangements.[85] As to the merging of the ARRAC, ARRTC and MSTCs, DEH was of the view that these organisations 'perform three very different roles, and no advantage would [be] gained by merging them.'[86]

- The GAC's sixth recommendation was to reform the 'system of Authorisation for uranium mining in the Alligator Rivers Region.'[87]

  Whilst the DEH stated that 'the GAC has not provided enough information here on the nature of possible reforms for the Authorisations process for any comment to be provided', it noted that Authorisations for uranium mining in the ARR are 'frequently reviewed and amended as required' through changes in operational practices.[88]

10.86 The GAC suggested that its first five recommendations could be satisfied by consolidating the provisions of a number of pieces of legislation and regulation, including the 17 November 2000 Agreement, the Working Arrangements, Part III of the Commonwealth *Atomic Energy Act 1953* and the EPARR Act.[89]

10.87 The ACF also made recommendations for regulatory reform, including a review of the regulatory regime in the NT to reduce complexity.[90] Each of these issues is addressed, in turn, in the following sections.

10.88 Arguing that the current regulations were in fact adequate, ERA reported that complying with regulatory requirements presented a significant cost to the company:

> The combined direct cost of all of our environmental, safety and health management activities, which includes payments to the Commonwealth Department of Environment and Heritage that are used to fund the Office of the Supervising Scientist, is well in excess of $10 million a year.[91]

10.89 The NTMC argued that companies advocate excellence in environmental performance and aim to achieve ISO 14001 certification—an

85 DEH, *Submission no. 55.2*, *loc. cit.*

86 DEH, *Submission no. 55.2*, *loc. cit.*

87 *loc. cit.*

88 DEH, *Submission no. 55.2*, *loc. cit.*

89 *loc. cit.*

90 ACF, *op. cit.*, p. 29.

91 ERA, *Exhibit no. 76*, *op. cit.*, p. 6.

internationally recognised standard for environmental management systems—which ERA has already attained.[92] In addition, all major operators in the NT are signatories to the Minerals Industry *'Enduring Value'* Code for Sustainable Development.[93]

10.90 In relation to environmental regulation, witnesses commented on a range of specific issues, which are detailed below:

- management of waste at mine sites;
- reporting requirements;
- mine closure and rehabilitation;
- operations in the Northern Territory; and
- operations in South Australia.

Waste

10.91 In relation to waste generated by uranium mining, witnesses were specifically concerned at tailings management and the management of waste water. An overriding concern of submitters was that uranium mining leaves behind tailings which stay radioactive for long time periods. Earth movements may damage tailings dams and cause radium to escape. Leaking waste water may also contaminate groundwater.[94]

10.92 Another concern involved the possibility of tailings moving into groundwater or being dispersed by air as radon.[95] GAC's fundamental concern was that during uranium mining and after rehabilitation there could be increased concentrations of radionuclides released into the environment.[96]

10.93 GAC made a number of allegations about the management of tailings at Ranger, including:

- deficiencies in the monitoring regime at Ranger and Jabiluka;
- culture of downplaying incidents by regulatory agencies;
- exclusion of Traditional Owners from decision making roles in relation to waste management; and
- lack of transparency in waste management and concern about its environmental impacts.[97]

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92 NTMC, *Submission no. 51*, p. 7; *ibid.*, p. 7.
93 NTMC, *ibid.*
94 Ms Janet Marsh, *Submission no. 2*, p. 1.
95 Mr Daniel Taylor, *Submission no. 85*, p. 10.
96 GAC, *op. cit.*, p. 36–37.
97 *ibid.*, p. 43.

DEH expressed its confidence in the current system of tailings management, provided the Committee with a detailed response to each of the GAC's concerns and explained how tailings are currently managed.[98]

10.94 The NT Government advised that Ranger pumps approximately 2.3 million tonnes of tailings per annum at a density of 50 per cent solids to pit number one. This equates to a total volume of about 3.2 million cubic metres of tailings per annum. The Territory Government noted that uranium mine tailings are *not* classified as radioactive waste.

10.95 The GAC raised four concerns about water management at Ranger:

- reduction in the statutory monitoring points in the lease area;
- need for extensive monitoring;
- extent of leaks and the need for modelling; and
- criticism of OSS for relying on company data.[99]

10.96 Again, DEH expressed its confidence in the current system of waste water management, and responded to each of the GAC's stated concerns.[100]

10.97 The GAC proposed that statutory responsibility for monitoring environmental impacts be transferred from the NLC to the GAC, but this suggestion was rejected by the NLC.[101]

Incidents and spillages at uranium mines

10.98 A number of submitters expressed concern at the 'large numbers of incidents' occurring at uranium mines, the alleged reluctance of regulators to prosecute companies and the inadequacy of penalties.[102]

10.99 FOE alleged that the present regulatory structure fails to enforce environmental protection by:

- operators and regulators not being required to improve practices;
- operators failing to report incidents promptly to regulators and to the public; and
- inadequate monitoring practices.[103]

98 DEH, *Submission no. 55.2*, pp. 4–6.
99 GAC, *op. cit.*, p. 46.
100 DEH, *Submission no. 55.2*, p. 16.
101 NLC, *Submission no. 78*, p. 10.
102 APChem, *loc. cit.*; FOE, *op. cit.*, p. 10.
103 FOE, *ibid.*, pp. 9–10.

10.100 FOE claimed that ERA has failed to report 'severe uranium contamination events' in a timely fashion:

> [In its annual report] ERA … stated that the company operates in accordance with applicable environmental legislation. However the directors' report fails to mention a number of severe uranium contamination events that occurred last year at ERA's Ranger mine. One notorious incident in March 2004 resulted in 28 workers falling ill after drinking water contaminated with uranium levels 400 times greater than the maximum Australian safety standard.[104]

10.101 GAC echoed this view, claiming that regulatory agencies operate within a culture of downplaying incidents. It cited an example of the OSS stating in its 2000–01 Annual Report that no reportable incidents had occurred during the reporting period, while the GAC stated that:

> A tailings spill such as that on 9 September 2000 is clearly of risk to mill workers, and would be of legitimate concern to the Mirarr and the general public. The Gundjeihmi Aboriginal Corporation is concerned that a poor management culture within ERA and regulating authorities that down play reportable incidents is a recipe for disaster.[105]

10.102 These concerns, however, were countered by the DEH, which responded that the number of reported incidents was not a cause for concern and merely reflected the stringency of the reporting regime.[106] It contended that this has resulted in the reporting of incidents that would be considered to be below the threshold level at other mining operations.[107]

Mine closure and rehabilitation

10.103 A number of submitters were concerned about failures to rehabilitate former uranium mines in the South ARR and at Nabarlek in the East ARR.[108] Environmental groups cited the environmental degradation following the closure of uranium mines in the NT which were not properly rehabilitated:

> There have been former uranium mining operations, from Rum Jungle through South Alligator, across the East Alligator River,

104 *ibid.*, p. 9.

105 GAC, *op. cit.*, pp. 35–6.

106 DEH, *Submission no. 55.1*, p. 4.

107 *ibid.*

108 ACF, *op. cit.*, pp. 27, 28; G. M. Mudd, *Exhibit no. 14*, *Uranium mill tailings wastes in Australia: past, present and future management*, p. 6; G. M. Mudd, *Exhibit no. 15*, *Remediation of uranium mill tailings wastes in Australia*, pp. 4–5; G. M. Mudd, *Exhibit no. 21*, *A compendium of radon data for the rehabilitation of Australian uranium projects*, p. 9.

> into the Nabarlek mine. Now there are continuing and unresolved rehabilitation issues at all of those sites.[109]

10.104 In particular, the Environment Centre of the Northern Territory (ECNT) argued that rehabilitation projects in the 1980s have merely reduced the rate of pollution.[110] It alleged that Rum Jungle continues to pollute the environment:

> … thousands of tonnes of potentially toxic pollutants such as copper, zinc, manganese, lead sulphate, uranium and radium were, and continue to be, washed into the Finniss River and adjacent wetland environments.'[111]

10.105 Mr John Schindler was also concerned that Rum Jungle remains contaminated, and questioned who is responsible for paying for the rehabilitation process in the event that the mine owner folds, which was the case with the Rum Jungle mine.[112]

10.106 Information available on the ARPANSA website was critical of the tailings management processes adopted at Rum Jungle, particularly during the early stages of mining, and noted that minimal rehabilitation was carried out on the site upon closure of the mine.[113] They argued that within a few years of closure:

> … the Rum Jungle mine had become one of Australia's most notorious pollution problems, due to oxidation of sulphides by bacteria and the consequent release of acid and metals into the East Finniss River.[114]

10.107 In relation to Nabarlek, ACF pointed to the physical plant that remains on the site, a lack of revegetation, high levels of radiation in some areas of the site, and an alleged failure of 'regulatory culture' and communication between agencies.[115]

10.108 Compass Resources observed that the earlier generation of uranium mines, such as Rum Jungle, were not subject to the approval processes that apply today and 'the regulations were very flimsy.'[116] Compass Resources argued that there are now 'substantially higher standards to meet' for

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109 Mr Dave Sweeney, *op. cit.*, p. 78.

110 Mr Peter Robertson (ECNT), *Transcript of Evidence*, 24 October 2005, pp. 1–2.

111 *ibid.*

112 Mr John Schindler, *Submission no. 10*, p. 2.

113 Crouch et al, *Rehabilitation of Uranium Mine Waste Sites in Australia*, p. 5, viewed 24 July 2006, <http://www.arpansa.gov.au/pubs/radwaste/frenchpaper.pdf>.

114 *ibid.*

115 Mr Dave Sweeney, *op. cit.*, p. 86.

116 Dr Malcolm Humphreys, *op. cit.*, p. 66.

product control, occupational health and safety, and for reclamation of the proposed mine site.[117]

10.109 The Supervising Scientist corroborated this view, arguing that:

> I would say that the regulations that apply today to uranium mining in Australia, as distinct from what used to occur, are such that the environment can be and has been protected to a very high degree. If one applied the same stringency to other forms of mining you could achieve the same result, but the other forms of mining do not receive the same kind of attention that uranium mining does.[118]

10.110 Notwithstanding problems at some mines, the rehabilitation of mines at Mary Kathleen and Nabarlek has been successful:

> The first major rehabilitation project of a uranium mine in Australia, Mary Kathleen in Queensland, won an award for engineering excellence upon completion in 1985, and the 1990s rehabilitation of Nabarlek is even better.[119]

10.111 The Director of Parks Australia noted that there are some 20 former mine sites in the upper South ARR dating from the 1950s and 1960s. Some of these sites were partially rehabilitated in 1990–91, before they became part of the Kakadu National Park. The sites are required to be properly rehabilitated by 2015 and planning work to achieve this commenced some five years ago. In partnership with the Traditional Owners, the NLC, the Supervising Scientist and the NT Government, Parks Australia reported that a plan has now been developed to remediate the simplest sites. This plan has been agreed to by the NLC and Traditional Owners.

10.112 Parks Australia reported that planning is now 'well under way' for dealing with the more complicated sites, but it was noted that at present National Parks does not have sufficient resources to properly rehabilitate all these sites: 'The scale of what is necessary to be done properly is beyond our current capacity.'[120]

10.113 In June 2006, the Australian Government announced that it will move to incorporate 29 mining leases into Kakadu National Park, allocating $7.3 million over the next four years for this work which will involve 'the

117 *ibid*.

118 Dr Arthur Johnston, *op. cit.*, p. 7.

119 AMEC, *op. cit.*, p. 6.

120 Mr Peter Cochrane (DEH), *Transcript of Evidence*, 10 October 2005, p. 10.

effective rehabilitation of abandoned uranium sites in Kakadu's South Alligator River valley'.[121]

10.114 Concerns about the rehabilitation of decommissioned mines were accompanied by requests by environmental groups for further resources for Parks Australia for its rehabilitation work on former sites.[122]

10.115 In terms of the Ranger operation, ERA observed that the company is obliged to submit an annual amended Plan of Rehabilitation, underwritten by a bond (which is now in excess of $60 million), setting out how the company would rehabilitate the site in case of sudden closure. The company states that the net present cost of final closure at the end of the operation's life is expected to be $176 million.[123]

10.116 The ACF alleged that both the Commonwealth and NT regulatory authorities have failed to give adequate regard and effect to minimising impacts on the Ranger Project Area despite this being clearly articulated in the Environmental Requirements. This failure has allegedly seen a consistent pattern of approvals being granted that increase ERA's contaminant footprint and complicate future rehabilitation and final landform options.[124]

10.117 In response, the NT Government confirmed that under the Territory's *Mining Management Act* and the mining management plans, companies are required to implement appropriate and approved mine closure processes.[125] As a part of this process, companies are required to provide an environmental bond held by the Government which, in the case of ERA's operations at Ranger noted above, is currently $63 million.[126] Furthermore, the Commonwealth's Environmental Requirements stipulate that the Ranger Project Area is to be rehabilitated such that it could be incorporated into the National Park.[127]

10.118 In relation to the rehabilitation of the mine site, Mr Harry Kenyon-Slaney explained the Environmental Requirements that ERA must meet:

> We have set out in our environmental requirements, which are attached to our lease, very clear regulations as to what we have to

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121 The Hon Greg Hunt MP, Parliamentary Secretary to the Minister for the Environment and Heritage, *Media Release: Old mining leases to become part of Kakadu*, Australian Government, Canberra, 5 June 2006, viewed 17 August 2006, <http://www.deh.gov.au/minister/ps/2006/psmr05jun206.html>.

122 ACF, *op. cit.*, p. 29.

123 ERA, *Exhibit no. 76, , op. cit.*, p. 7.

124 ACF, *op. cit.*, pp. 21–2.

125 Mr Richard Jackson, *op. cit.*, p. 61.

126 *ibid.*

127 DEH, *Submission no. 55*, p. 16.

> achieve. We are required to return the ground, the five square kilometres, to a standard which will allow its incorporation into the Kakadu National Park. That is a very considerable obligation and it is one that we have already started work on. We are required to remove all infrastructure. We are required to move the power plant. We are required to remove everything to do with the mine site and put the waste rock back into the pit, fill them up and rehabilitate all of the water. We have recently constructed a $30 million water treatment plant to start the process of lowering water kept on site. Progressively, over the next five or six years before formal closure, we will move ahead with a range of technical projects to ensure that closure proceeds in an exemplary manner. I think we will be in the vanguard of scientific best practicable technology by the time we close Ranger, and I have every confidence that we will do it in an exemplary manner. But I think the issues are going to be more socioeconomic than technical.[128]

10.119 ERA is aware that the future of the community in the vicinity of Ranger will depend in large measure on the company's ability to prepare for closure. Mr Kenyon-Slaney stated that the company has commenced a comprehensive closure management process and will be providing for it financially. ERA expressed that it is determined to 'close Ranger in an exemplary manner', but argued that the biggest challenge is likely to be the socio-economic implications of the mine's closure:

> I think the most significant issues and probably the most vexing of issues are going to be in the socioeconomic area, where the reliance upon Ranger in the community is very significant. Upwards of 70 per cent of the town of Jabiru is in one way or another connected with, or dependent upon, Ranger's operation. We are working very actively with all the stakeholders, the traditional owners, the Northern Territory government, and Parks to try to ensure that those issues are addressed and that we can withdraw from the area in as sustainable a manner as possible.[129]

10.120 Although ERA is obligated under the Environmental Requirements attached to its mining license to remove the infrastructure at Ranger, including the power station which also supports Jabiru, the company will discuss with stakeholders what is to happen to the infrastructure:

> … to try to ensure that we leave a sustainable community. We will be working over the next seven years or so to find ways of doing

128 Mr Harry Kenyon-Slaney, *op. cit.*, p. 52.

129 *ibid.*, p. 51

> that, whether it is through employment, development for small businesses or opportunities to leave infrastructure that is of use to people in the future.[130]

10.121 In preparing for closure, ERA explained that in the past few years a Jabiru Regional Sustainability Project was initiated in partnership with the Traditional Owners, the NT Government and Parks Australia which had as its objective to understand what the impact is going to be on the community from the closure of the mine.[131]

10.122 The Committee concludes that the regulations governing uranium mine closure and rehabilitation are clearly now much improved over past requirements and practice. Recognising the importance of successfully rehabilitating decommissioned uranium mines, and taking into account the risks posed by poorly rehabilitated former mines, the Committee supports calls for increased funding to rehabilitate former uranium mines.

10.123 The Committee applauds ERA's determination to eventually close Ranger in a way that leaves behind a sustainable community.

Recommendation 5

The Committee recommends that the Australian Government provide adequate funding to ensure the rehabilitation of former uranium mine sites, and for towns and similar facilities, rehabilitation to meet the expectations of the local community.

Operations in the Northern Territory

10.124 The ECNT argued that the regulation of uranium mining in the NT operates 'through a confused tangle of legislation, ministerial agreements and bureaucratic processes.'[132] It was alleged that the 'regulatory mess' has 'marginalised the local Aboriginal people and contributed to the long-running mismanagement of the [Ranger] mine.'[133]

Impacts of mining on the Kakadu National Park

10.125 A number of submitters claimed that the existing monitoring and reporting regime in the ARR is inadequate.[134] The ACF alleged that the regulatory frameworks are failing to protect the environment in Kakadu,

130 *ibid.*, p. 55.

131 *ibid.*, p. 56.

132 Mr Peter Robertson, *op. cit.*, p. 2.

133 *ibid.*

134 ACF, *op. cit.*, pp. 18–21; Mr Justin Tutty, *op. cit.*, p. 5; FOE, *loc. cit.*

leading to 'unacceptable and unnecessary operational and procedural failures.'[135]

10.126 The ECNT alleged that the Australian Government has failed to act on a previous commitment to support a recommendation of the World Heritage Bureau to incorporate the proposed Koongarra mine area into Kakadu.[136]

10.127 Notwithstanding the concerns expressed by the GAC and environmental groups, the NLC stated that it was no more concerned about the environmental impacts of uranium mining than it was about any other mining that takes place. Indeed, the NLC expressed more concern about the impacts of mining to extract gold.[137]

10.128 The Director of Parks Australia, Mr Peter Cochrane, stated that uranium mining poses a low risk for the Park:

> In terms of the risk issues that we deal with in managing the park and protecting its values, I would have to say that Ranger uranium mine and its impact on the landscape are very low down on that risk profile. There are a range of issues which are much higher priorities for us. It is not something that impacts on us greatly. I have every confidence that the Supervising Scientist and his staff prosecute their job with the utmost efficiency and effectiveness. Therefore, the mine, in terms of park management, does not have a major impact.[138]

10.129 It was noted that the major issue would be the rehabilitation effort following the closure of the mine, but that:

> Kakadu is well known around the world for having probably the best managed mining operation in a World Heritage area, one which has a minimal impact on the area.[139]

10.130 The Supervising Scientist noted that his office had fully assessed the possible environmental impacts from the management of tailings were the Jabiluka mine to proceed in a report for the World Heritage Committee. It was found that the requirement that tailings be placed underground would generate 'no impact in the very, very long term on the environment'.[140] Thus, contrary to assertions by ACF and Dr Gavin Mudd, the OSS has assessed that long-term storage of tailings underground at

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135 ACF, *ibid.*, p. 21. See also: Mr Justin Tutty, *ibid.*, p. 7.

136 Mr Peter Robertson, *op. cit.*, p. 3.

137 Mr Norman Fry (NLC), *Transcript of Evidence*, 24 October 2005, p. 21.

138 Mr Peter Cochrane, *op. cit.*, p. 8.

139 *ibid.*

140 Dr Arthur Johnston, *op. cit.*, p. 12.

Jabiluka will not harm the wetlands of Kakadu. Moreover, in 2000, the World Heritage Committee concluded that:

> … the currently approved proposal for the mine and mill at Jabiluka does not threaten the health of people or the biological and ecological systems of Kakadu National Park.[141]

10.131 For its part, ERA noted that the Supervising Scientist's reports have 'continually stated that ERA's operations have never adversely affected the ecosystems of the Park.'[142]

Incidents at Ranger

10.132 ACF expressed concern about the environmental impacts and safety of the operations at Ranger:

> We have a current operation system at Ranger, where there are significant environmental and significant social impacts from that large-scale industrial activity … We have a situation where last year the Ranger uranium mine workers showered in and drank water containing 400 times the Australian safety standard of uranium. This year there are continuing health and safety challenges and prosecutions in court in Darwin. There is growing radioactive contamination in the footprint of the current mine.[143]

10.133 Similarly, the ECNT drew the Committee's attention to the incident in which workers were exposed to contaminated water and alleged that, by not responding to the Senate inquiry into Ranger the Commonwealth is 'showing that it is not interested in protecting the environment, workers or the community in relation to uranium mining in the Northern Territory.'[144]

10.134 The ECNT alleged that mining at Ranger has caused elevated levels of toxic contaminants downstream of the mine and is also producing a contaminated groundwater plume arising from a supposedly leaking tailings dam.[145]

10.135 The Supervising Scientist noted that over the life of the Ranger mine there have been some 120 occasions on which formal reporting of an incident was required. However, until 2004 when two serious incidents occurred, there had only been one incident over the past 25 years in which people were affected by a very small radiation dose and one other in which a number of birds died on a pond at the mine. The Supervising Scientist

141 Cited in DEH, *Submission no. 55.1*, p 7.
142 Mr Harry Kenyon-Slaney, *op. cit.*, p. 47.
143 Mr Dave Sweeney, *op. cit.*, p. 78.
144 Mr Peter Robertson, *op. cit.*, pp. 2–3.
145 *ibid.*, p. 2.

'assessed that all the other 120-odd incidents as being of negligible impact on the environment.'[146]

10.136 In relation to the two incidents that occurred at Ranger in 2004, the Supervising Scientist again concluded that although the incidents were 'very serious in that they did threaten the health of both people and the environment', it is expected that there 'will be no long-term health hazard for the workers involved and the environment was protected to a very high degree during the entire incidents.'[147]

10.137 In relation to an incident involving a leakage of tailings water in 2000, DEH argued that the ACF were incorrect in their assertion that 2 million litres had left the mine site. The actual figure was only 85 000 litres and the Supervising Scientist had subsequently concluded that 'the leakage of tailings water had no adverse ecological impact on Kakadu National Park.'[148]

10.138 Mr Kenyon-Slaney stated that the incidents that occurred at Ranger in 2003 and 2004, which related to the contamination of the potable water system and pieces of equipment leaving the mine site, were unacceptable. While it was argued that there were no health impacts, the incidents breached the company's own internal standards and procedures. The Supervising Scientist investigated and reported on the incidents and these reports were followed by an audit launched by the Australian Government. Mr Kenyon-Slaney explained that ERA complied with the requirements of all three audits and has put in place:

> … a whole series of new procedures and practices which strengthened our compliance with our water systems in the plant and the radiation clearance procedures. Those have been signed off and given a ringing endorsement by ARPANSA.[149]

10.139 In sum, ERA argued that it had acknowledged recent failures, taken actions deemed satisfactory to regulators and expressed a desire to improve performance.[150] The Minister for Industry, Tourism and Resources' view was that ERA had made considerable progress towards meeting conditions arising out of two Supervising Scientist reports: the company had complied with all conditions but one, and had made

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146 Dr Arthur Johnston, *op. cit.*, p. 6

147 *ibid*.

148 DEH, *Submission no. 55.1*, p. 3.

149 Mr Harry Kenyon-Slaney, *op. cit.*, p. 53.

150 See for example: ERA, *Social and Environmental Report*, ERA, Darwin, 2005, viewed 10 July 2006, <http://www.energyres.com.au/corporate/ERA_SE_Rep05ART.pdf>.

substantial progress towards complying with the final condition relating to a workplace safety standard.[151]

10.140 As to the robustness of regulatory oversight and the two incidents at Ranger, the NT Government pointed out that the Territory's *Mining Management Act* places a duty of care on companies to conduct themselves in a certain way. In addition to mechanisms such as the MSTCs, an environmental audit is performed by the Government once a year to ensure that management systems are in place. In relation to the incident in which contaminated equipment left the mine site, the NT Government stated that these incidents were identified and reported, as required, by ERA:

> We do not have anybody on the gate to check whether or not equipment is leaving the site with mud on the tyres. ERA is supposed to do that. They know they were supposed to do that. They fell down on that occasion and they brought that to the attention of government. From that point of view, I suggest that the system is working … absolutely. If they did not bring it to our attention, then we probably would not have known about it, but we work within a regulatory environment where people will bring that to our attention.[152]

10.141 As to the number of incidents that have been reported, the Supervising Scientist concluded that this reflects the stringency of the reporting regime rather than reflecting adversely on the company's performance:

> In absolute environmental protection terms, the record of the company has been very good. It is my view that the reason why we have so many incidents reported is that it is more a measure of the stringency of the reporting regime that is imposed on the company by the regulations than it is a reflection on the company's performance.[153]

10.142 DEH concurred, responding that the number of reported incidents at Ranger is indicative of the rigorous reporting regime, which has resulted in the reporting of incidents that would be considered to be *below* the threshold level at other mining operations.[154] Moreover:

> Monitoring and research by the Supervising Scientist since 1978 has concluded that there has been no harm to the environment in

151 Supervising Scientist, *Annual Report 2004–05*, Department of the Environment and Heritage, Australian Government, Canberra, 2005, pp. 34–5.

152 Mr Richard Jackson, *op. cit.*, p. 65.

153 Dr Arthur Johnston, *op. cit.*, p. 6.

154 DEH, *Submission no. 55.1*, p. 4.

> Kakadu as a result of mining operations at Ranger, confirming the efficacy of the regulatory regime.[155]

Operations in South Australia

Expansion of Olympic Dam

10.143 The ACF and other submitters argued that there are four 'significant and unresolved issues' associated with the proposed expansion of Olympic Dam: the long-term management of radioactive mine tailings; potential for the degradation of the Great Artesian Basin (GAB), if additional water supplies were to be sourced from the GAB; the significant power demand for the expanded mine; and the provisions of the Indenture Act under which the mine operates, which are alleged to provide the mine operator with 'unacceptable legal privileges'.[156] For instance, the FOE claimed that the *Roxby Downs Indenture Ratification Act* overrides the SA *Aboriginal Heritage Act*.[157]

10.144 A number of submitters were concerned about possible increases in tailings at Olympic Dam if the mine is expanded.[158] For instance, Dr Gavin Mudd noted that Olympic Dam is:

> … already Australia's largest single radioactive waste dump, currently about 73 million tonnes and growing by some 9 million tonnes per year. This radioactive waste dump, the tailings left from milling and smelting, has leaked profusely in the past. If the full ore resource is ever mined at Olympic Dam … the tailings dump could reach some 4,000 million tonnes …[159]

10.145 Similarly, ACF claimed that the increased tailings from the expansion of operations at Olympic Dam will:

> … massively increase the scale of the current problem without providing any credible answer to tailings containment.[160]

10.146 The proposed expansion was also criticised for its increased power and water requirements from the GAB.[161] ACF claimed that:

155 *ibid.*

156 Mr David Noonan (ACF), *Transcript of Evidence*, 19 August 2005, p. 78.

157 FOE, *op. cit.*, p. 15.

158 G. M. Mudd, *Exhibit no. 13*, *Mound springs of the Great Artesian Basin in South Australia: a case study from Olympic Dam*, p. 474; ACF, *op. cit.*, pp. 8–9; FOE, *op. cit.*, p. 10.

159 Dr Gavin Mudd, *Submission no. 27*, p. 8. See also: G. M. Mudd, *Exhibit no. 14*, *loc. cit.*

160 ACF, *op. cit.*, p. 7.

161 Dr Gavin Mudd, *Submission no. 27*, p. 8; ACF, *op. cit.*, p. 7.

> Mining demands on water supply threaten the Great Artesian Basin and the unique Mound Spring ecosystems dependent on natural groundwater flows for their survival.[162]

10.147 Dr Gavin Mudd asserted that the average ore grade at Olympic Dam will decline over time, leading to higher energy requirements for extraction and more radioactive waste created per tonne of U_3O_8 produced.[163] ACF was also opposed to the expansion of Olympic Dam on the basis that the operation's energy requirements had yet to be resolved, and that the additional power requirements would impose burdens on the State's electricity grid.[164]

10.148 The ACF also asserted that the owners of Olympic Dam operate the mine 'under a set of privileges available to no other company operating in SA' and that 'the State Government should repeal these unacceptable legal privileges'.[165]

10.149 BHP Billiton contested this view, stating that Olympic Dam has and continues to be subject to a range of environmental management systems and requirements. These include:

- registration and accreditation under the National Standards Association 14000 series;
- three-year environmental management programs under the Indenture Agreement with the SA Government;
- annual environmental management reports to both the SA and Australian Governments;
- six-monthly environmental management meetings with both the state and federal governments; and
- quarterly environmental management meetings on-site with the SA Government.[166]

10.150 In relation to the extraction of water from the GAB, BHP Billiton argued that the company already recycles and desalinates water, both for its mining processes and for consumption at Roxby Downs. Moreover, the company has spent several million dollars in support of the State Government's program of capping pastoral bores and argued that, in combination, these efforts save the same amount of water that Olympic Dam uses. Dr Roger Higgins, Vice President and Chief Operating Officer of BHP Billiton's Base metals Australia, argued that:

162 ACF, *ibid.*, pp. 7, 8. See also: Dr Gavin Mudd, *ibid.*

163 Dr Gavin Mudd, *ibid.*, p. 4.

164 ACF, *op. cit.*, p. 9.

165 *ibid.*, pp. 7, 8.

166 BHP Billiton Ltd, *Exhibit no. 78, Presentation by Dr Roger Higgins*, p. 10.

> Collectively, those programs have resulted in reduced water being extracted from the GAB of about twice what we use. We consider that our contribution to that is about equal to what we use. So, while we take 32 megalitres a day out of the Great Artesian Basin, by working with the pastoralists helping to cap bores, to put covered piping in rather than open drains and generally to avoid losses, we believe that we are about in balance in our total effort in relation to the GAB. That is, the water extracted is roughly equivalent to the water saved by a more judicious use of water on the pastoral properties. It has been a good program.[167]

10.151 The expanded mine will require 130 megalitres of water a day, up from 30 megalitres currently, and BHP Billiton is examining three possible sources of supply: further use of the GAB; other aquifers in the region that are not connected to the GAB; and a desalination plant. If the company were to opt for the desalination plant, it expressed the hope that communities in the region could also benefit from the facility.[168]

10.152 DEH noted that the potential environmental impact of any expansion of Olympic Dam will be formally assessed during the approval process. DEH expected that such matters 'will be subject to a very thorough examination through the EIS process.'[169]

Beverley and Honeymoon deposits

10.153 A number of submitters were concerned about allegedly 'severe groundwater pollution caused by acid ISL mining' at Beverley and Honeymoon.[170] Dr Gavin Mudd insisted that the ISL mining technique contaminates groundwater, and alleged that no scientific evidence to the contrary has yet been produced.[171] Specific criticisms were made of: the use of acid in the leachate at Beverley; re-injection of waste liquids into the aquifer; and the potential for excursions of contaminated groundwater into other aquifers.[172]

10.154 Dr Mudd argued that there is no scientific evidence of claims that the waste liquid re-injected into the aquifer at Beverley will naturally

167 Dr Roger Higgins (BHP Billiton Ltd), *Transcript of Evidence*, 2 November 2005, pp. 10–11.

168 *ibid.*, p. 11.

169 Mr Gerard Early, *op. cit.*, p. 21.

170 Dr Gavin Mudd, *Submission no. 27*, p. 8; Mr John Schindler, *Submission no. 10*, p. 1;

171 Dr Gavin Mudd, *ibid.*. See also: G. M. Mudd, *Exhibit no. 16*, *Critical review of acid in situ leach uranium mining: 1. USA and Australia*, pp. 401–2; G. M. Mudd, *Exhibit no. 17*, *Critical review of acid in situ leach uranium mining: 2. Soviet Block and Asia*, pp. 414–5; G. M. Mudd, *Exhibit no. 19*, *Environmental hydrogeology of in situ leach uranium mining in Australia*, pp. 56–7; G. M. Mudd, *Exhibit no. 20*, *Uranium mill tailings in the Pine Creek Geosyncline, northern Australia: past, present and future hydrogeological impacts*, p. 839.

172 FOE, *op. cit.*, p. 8; Mr John Schindler, *op. cit.*, p. 1.

attenuate—that is, over a period of time the composition of the waste liquid will naturally return to its precontaminated state. It was also argued that Heathgate Resources, the mine's owners, have yet to release any research refuting his published criticisms of acid ISL mining.[173] However, Dr Mudd conceded that: 'There is an extremely remote possibility that Beverley could affect the Great Artesian Basin'.[174]

10.155 In response to claims that acid ISL mining of uranium and disposal of wastes will contaminate groundwaters, in 2003 the SA Government requested that the State's Environment Protection Authority conduct an independent review of the environmental impacts of the ISL mining process. CSIRO Land and Water was commissioned to conduct the review, which was completed in August 2004. The CSIRO review methodology consisted of visits to the Beverley and Honeymoon operations, a study of company and government documents, a literature review (the bibliography of the CSIRO report lists several of Dr Mudd's publications), consultation with the community, and consideration of written submissions.[175]

10.156 The CSIRO's overall conclusion was that ISL mining has considerably less environmental impact than other conventional mining techniques. As to the use of acid rather than alkaline leaching and disposal of liquid wastes by re-injection into the aquifer, the report concluded that these processes should be allowed to continue, subject to monitoring showing that there are no excursions of leach solution or waste liquids into other aquifers. The report stated that ISL mining and associated waste disposal is more environmentally responsible and cost effective than any suggested alternative techniques. Furthermore, CSIRO concluded that the Beverley operation has initiated and implemented world best practice methods.[176]

10.157 In reaching these conclusions, the CSIRO noted that the pre-mining groundwater at Beverley was highly saline and contained relatively high concentrations of radionuclides. In its untreated form, the groundwater was unsuitable for human consumption and generally unsuitable for stock use. The groundwater has no apparent beneficial use other than for the mining industry. Further, the study found that re-injection of waste is preferable to surface disposal. CSIRO concluded that although it has not yet been proven, it is widely believed and accepted that natural attenuation will result in the contaminated water chemistry returning to

173 Dr Gavin Mudd, *Submission no. 27*, p. 8. See also: G. M. Mudd, *Exhibit no. 16, loc. cit.*; G. M. Mudd, *Exhibit no. 17, loc. cit.*; G. M. Mudd, *Exhibit no. 19, loc. cit.*; G. M. Mudd, *loc. cit.*

174 Dr Gavin Mudd, *Transcript of Evidence*, 19 August 2005, p. 46.

175 G Taylor et. al., *loc. cit.*

176 *ibid.*, pp. iii, 47.

pre-mining conditions within a timeframe of over several years to decades.[177] Finally, CSIRO considered that there is 'no potential for mining-affected water from the Beverley project to enter the GAB.'[178]

10.158 However, Dr Mudd claimed that the CSIRO report provided 'no data to justify their claims that there would be no long-term impacts on groundwater.'[179] Dr Mudd also criticised the CSIRO report because it was 'not based on good science'.[180]

10.159 Heathgate Resources rejected the criticism made of the appropriateness of the ISL mining method used at its Beverley operation and defended the CSIRO study.[181]

The Supervising Scientist

10.160 The ACF made a number of criticisms specifically concerned with the OSS and DITR.[182] Each concern raised is followed by a response from DEH in turn:

- The ACF was critical of the alleged reduction of a Commonwealth 'on-the-ground' presence in Kakadu.[183]

  Whilst the DEH confirmed that ERISS staff had relocated from Jabiru to Darwin in 2002, it argued that the OSS's on-ground presence had increased since that time.[184] The OSS now has 'a full chemical, radiological and biological monitoring program and all of the staff conducting this program reside at Jabiru', and this was not the case prior to 2001.[185] Furthermore, since 2002, the OSS 'has had a person located in Jabiru who is in a position to respond quickly to incidents at the [Ranger] mine.'[186]

- The ACF was also critical of what is perceived as 'the repeated unwillingness or inability of the OSS to uphold the integrity of the Environmental Requirements by using the full suite of options, including legal action'.[187]

177 *ibid.*, p. 44.
178 *ibid.*, p. 23. See also: Mr Mark Chalmers, *op. cit.*, pp. 98–99.
179 Dr Gavin Mudd, *Transcript of Evidence*, *op. cit.*, p. 47.
180 *ibid.*, p. 48.
181 Mr Mark Chalmers, *loc. cit.*
182 ACF, *op. cit.*, pp. 21–3.
183 *ibid.*, p. 22.
184 DEH, *Submission no. 55.1*, p. 4.
185 *ibid.*
186 *ibid.*
187 ACF, *op. cit.*, p. 22.

The DEH refuted this claim, stating that OSS programs are directed at ensuring the adherence to Environmental Requirements.[188] The supervisory program ensures their implementation, and the monitoring program ensures compliance with Environmental Requirements.[189] In relation to the suggestion that the OSS pursue legal action, the DEH noted that 'the Supervising Scientist has only an advisory role' and that decisions relating to taking legal action are for the NT regulator or the Australian Government Minister for Industry, Tourism and Resources.[190]

- The ACF was concerned about the degree of the alleged regulatory capture and the organisational independence of the OSS, which it claimed was dramatically evidenced by the movement of the former Assistant Secretary to a senior management position at ERA during the 2003 contamination investigation.[191]

  The DEH rejected criticisms of the OSS's independence and refuted claims that the OSS had been captured by industry.[192] It suggested that the Supervising Scientist's independence had been demonstrated by the 'thoroughness and impartiality of investigations conducted on incidents at Ranger in 2000, 2002 and 2004' and the highly critical reports that resulted from these investigations.[193] The DEH noted that the NT Government had used two OSS reports as the basis for a successful prosecution of ERA, concluding that the OSS was therefore 'not subject to regulatory capture.'[194] It was also argued that the acceptance by an OSS staff member of a position with ERA was 'not evidence of a decline in the organisational independence of the Supervising Scientist.'[195]

- The ACF was disappointed with what it perceived to be the inadequate funding of the OSS.[196]

  In contrast, the DEH stated that 'the funding currently provided to the Supervising Scientist is considered adequate' for the fulfilment of the OSS's functions.[197] It noted that the ARRTC can recommend, if it believes it is necessary, that additional funding be provided to the

188 DEH, *Submission no. 55.1*, *loc. cit.*
189 *ibid.*
190 *ibid.*
191 ACF, *loc. cit.*
192 DEH, *Submission no. 55.1*, pp. 4–5.
193 *ibid.*
194 *ibid.*, p. 5.
195 *ibid.*
196 ACF, *loc. cit.*
197 DEH, *Submission no. 55.1*, *loc. cit.*

ERISS, and that no such recommendation had been made in the last five years.[198]

- The ACF also believed that the OSS relied too heavily on 'data, processes and analyses provided by ERA'.[199]

  The DEH refuted this claim, noting that the OSS runs an 'independent chemical, biological and radiological monitoring program' in the ARR, and it is on the basis of this data, not only those produced by ERA, that the OSS reaches its conclusions.[200] The DEH added that all of the data collected by the OSS is made public as quickly as possible, through the OSS website, Annual Report, and biannual reports to ARRAC.[201]

- The ACF was critical of the OSS allegedly 'prioritising ERA's operational needs over other considerations'.[202]

  The DEH rejected this claim, on the basis that it did not believe there was any evidence to support the assertion.[203] Indeed, correspondence between the OSS and ERA, made public in the former's report into the 2004 Ranger water contamination incident, demonstrates the OSS's determination to ensure that 'the environment and health of workers and the local people would not be put at risk' despite ERA's operational considerations.[204]

- The ACF condemned the OSS for allegedly failing to adequately engage Traditional Owners or reflect their concerns.[205]

  The DEH countered this assertion, noting that the OSS has a full-time employee in Jabiru whose specific role involves communication and engagement with the Traditional Owners on a daily basis. It also noted that the Executive Officer of the GAC had recently 'stated publicly that the Traditional Owners trusted the Supervising Scientist.'[206]

- Finally, the ACF was critical of the perceived over-reliance of the OSS on voluntary and informal undertakings between agencies and ERA.[207]

  The DEH noted that no reason had been given for the ACF's assertion.[208]

198 *ibid.*
199 ACF, *loc. cit.*
200 DEH, *Submission no. 55.1*, *loc. cit.*
201 *ibid.*
202 ACF, *loc. cit.*
203 DEH, *Submission no. 55.1*, *loc. cit.*
204 *ibid.*
205 ACF, *op. cit.* , p. 23.
206 DEH, *Submission no. 55.1*, *loc. cit.*
207 ACF, *loc. cit.*

10.161 Responding to a proposal to merge ERISS with ARRAC and split the combined organisation from the SSD, the Supervising Scientist advised that this had been considered and rejected on a number of occasions. It was argued that the current model has the important benefit of being able to provide the Supervising Scientist with immediate capacity and 'expertise on hand immediately', should the need arise—as was required with the potable water contamination incident at Ranger in 2004:

> We were able to respond instantly, essentially, to that incident. I was able to go out to Jabiru within days of the incident and assure the workers and the people of Jabiru that we had already measured the radionuclide content of the water and that no one had received a significant radiation dose. That was possible only because I was able to turn to my institute immediately and say, 'I need you off. Stop doing everything you're doing and work on this.'[209]

10.162 The NTMC was supportive of the role of the OSS:

> … the Minerals Council supports the work of the Office of Supervising Scientist and believes that the office is independent in its work and completely impartial and unbiased in its reviews and regulation.[210]

10.163 Among the ACF's recommendations for reforming the regulatory environment, was the suggestion that the 'on-ground' role of the OSS be expanded.[211]

10.164 The Committee notes the important function performed by the OSS, but that this is limited to oversight of uranium mines in the ARR of the NT. The Committee considers that the expertise of the OSS could perhaps be utilised in relation to approvals and monitoring of other uranium mines throughout Australia. In particular, the Committee notes that under the EPBC Act the Minister for the Environment must assess and approve proposals for new uranium mines or the expansion of existing mines. Expanding the scope of the Supervising Scientist's responsibilities to examine and monitor all future uranium mines may have merit, for example, in providing the most thorough analysis and advice to the Environment Minister.

10.165 The Committee notes evidence by industry that, in the main, state governments regulate mining very effectively and that the industry

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208 DEH, *Submission no. 55.1*, p. 6.

209 Dr Arthur Johnston, *op. cit.*, p. 7.

210 Ms Kezia Purick, *op. cit.*, p. 33.

211 ACF, *op. cit.*, p. 29; GAC, *op. cit.*, pp. 33–4.

wishes to see any unnecessary duplication across levels of government eliminated. Mindful of the importance of minimising further burdens on industry, the Committee urges that any expanded role for the OSS minimise any additional complexity for industry.

Recommendation 6

The Committee recommends that the Australian Government examine expanding the role performed by the Office of Supervising Scientist (OSS) in relation to the monitoring and approvals for uranium mines. As an example, the OSS could be given a formal role in advising the Minister for the Environment and Heritage in relation to all uranium mine assessments and approvals under the *Environment Protection and Biodiversity Conservation Act* and the Minister for Industry, Tourism and Resources in relation to the conditions for granting uranium export licenses.

Given the proposed expanded role for the OSS, the Committee further recommends that the Environmental Research Institute of the Supervising Scientist (ERISS) be provided with additional resources, potentially in partnership with a suitable university, so as to provide a national research function. The OSS should continue to be able to refer matters to ERISS for research, but ERISS's autonomy should be preserved in terms of the conduct of research and the release of its findings.

10.166 The ECNT raised concerns of staff moving between ERA, the OSS and the NT Department of Mines:

> … over the years there has been quite a steady flow of personnel between senior management of the Office of the Supervising Scientist and the uranium mining company itself and also the Northern Territory Department of Mines. So you have what can appear to a bit of a revolving door happening, where you have got the regulators moving off to work for the company and then company people going off to work for the regulators and it all starts to become pretty murky.[212]

10.167 ACF also alleged regulatory capture of the OSS by the uranium industry, and specifically by ERA.[213] The Supervising Scientist responded that:

212 Mr Peter Robertson, *op. cit.*, p. 7.

213 ACF, *op. cit.*, p. 22.

> … I find it strange that anyone could suggest that the Supervising Scientist has been captured by the industry when you look at the number of inquiries we have conducted over the last five years and at the reports that I have given to the minister, which have been tabled in the parliament and which have been highly critical of the ERA. Indeed, if you look at the water contamination incident that occurred last year you will see in the report that we wrote all the correspondence between me, the mining company and the Northern Territory regulator. You will find that it is absolutely clear in that correspondence that I insisted that, before I would support recommencement of milling activities, I would need to be absolutely convinced that all necessary steps had been taken to ensure that an incident of that kind could not be repeated. As a result, the mining company could not operate for 14 days. That is a very significant impost on any operation and financially a very significant cost.
>
> So I refute any suggestion that there was regulatory capture. It is not just a statement; I think the evidence is quite clear in the way we have conducted ourselves over the years and in the reports that we have written.[214]

10.168 The Territory Government listed the type and frequency of monitoring, audit and inspection undertaken of the Ranger mine site, as well as the environmental monitoring of surface and groundwater around the mine.[215] The NT Government rejected claims of regulatory capture by ERA and over reliance on company derived data:

> Yes, Ranger does monitoring and provides results to us and the Supervising Scientist, and I understand that is publicly available … No, we do not rely on that advice. Both the Northern Territory government and the Commonwealth do what we call 'check monitoring programs'. They do not always know when we are going there. We take samples. We get our own results and the Commonwealth gets their own results. We would look at those results against ERA's results at approximately the same time—maybe even at the same time—and if there were any anomalies there we are onto that.[216]

214 Dr Arthur Johnston, *op. cit.*, pp. 12–13.

215 Mr Keith Tayler (NT Government), *Transcript of Evidence*, 24 October 2005, pp. 62–64.

216 Mr Richard Jackson, *op. cit.*, p. 60.

Agency conflicts of interest

10.169 A number of submitters alleged that there is a failure to properly separate regulatory and industry development support functions within state and territory governments. Dr Gavin Mudd criticised the current regulatory framework for what he perceived to be a 'fundamental conflict of interest'.[217] Dr Mudd's concerns related to the potential for agency-based conflicts of interest due to the incongruous roles of agencies as both promoters and regulators of the uranium industry:

> There is a fundamental conflict of interest for a department of mines type of agency, whether it is in South Australia or the Northern Territory, to be both the active promoter and developer of the mining industry and its environmental regulator. They need to be separate … If they are legislated to be both a promoter and a regulator, that is a fundamental conflict of interest. They cannot do their job properly because in one sense they want to promote the industry but in the other sense they cannot regulate it to the extent that it really needs in order to meet legitimate community expectations. Olympic Dam is a good case study because most of the powers for normal regulation of most types of mining do not apply because of the Roxby Downs Indenture Act.[218]

10.170 The ECNT called for the creation of a regulator:

> … that is open and transparent, does not have conflicts of interest, is not subject to manipulation by the government or minister of the day, and does its job diligently. So far, we are still waiting to see that in relation to uranium mines in the Northern Territory.[219]

10.171 The NT Government argued that following a recent regulatory review, new mechanisms have now been put in place:

> … to make sure that those development issues are kept separate from the regulatory issues to the point where we could come to loggerheads with our mine development people if we thought there were issues there.[220]

10.172 While industry were appreciative of the Commonwealth's decision to intervene in the approvals process for uranium mining in the NT, the ECNT expressed opposition:

> The Commonwealth has said that it intends taking over the approval of new uranium mines in the Northern Territory but the

217 Dr Gavin Mudd, *Submission no. 27*, p. 14.

218 Dr Gavin Mudd, *Transcript of Evidence*, *op. cit.*, pp. 43–44.

219 Mr Peter Robertson, *op. cit.*, p. 7.

220 Mr Richard Jackson, *op. cit.*, p. 66.

> Commonwealth has shown over many decades that it cannot be trusted with uranium mines in the Northern Territory. From Rum Jungle to Ranger and Koongarra to Jabiluka, the Commonwealth has always put commercial gain and perceived political and strategic interests ahead of the environment, Indigenous people, public health and safety and future generations.[221]

10.173 ECNT felt that although they were members of the ARRAC the information on which decisions are based is not available to the ECNT.

10.174 In the remainder of the chapter, the Committee considers issues associated with the impact of uranium mining on Aboriginal communities.

Aboriginal communities and uranium mining

10.175 The Committee received evidence in relation to the social impact of uranium mining on Aboriginal communities. This included concerns regarding the present regulatory environment in providing adequate consultation and benefits for Traditional Owners and Aboriginal groups. Four specific issues are described in further detail below:

- social impact monitoring;
- consultation practices and processes;
- employment and training opportunities; and
- limitations of the *Aboriginal Land Rights Act*.

Social impact monitoring

10.176 One specific concern expressed by submitters was an alleged lack of reporting and attention given to cultural and social impacts and the failure to adequately or appropriately engage Aboriginal Traditional Owners. For example, APChem argued that the social impacts of uranium mining have not been adequately examined.[222]

10.177 The NLC stated that uranium mining has had an 'profound effect' on the lives of Aboriginal people in the ARR. Justice Fox allegedly predicted negative impacts of uranium mining on local Aboriginal communities, and the NLC assessed that these consequences have come to pass.[223] The GAC concurred with this view, alleging that uranium mining has been socially destructive for Aboriginal communities.[224] The Medical

221 Mr Peter Robertson, *op. cit.*, p. 1.

222 APChem, *op. cit.*, p. 6.

223 NLC, *op. cit.*, p. 7.

224 GAC, *op. cit.*, pp. 48-9.

Association for the Prevention of War (MAPW) claimed that the further development of the uranium industry in Australia would only add to the burdens of Aboriginal communities.[225]

10.178 Several submitters were critical of uranium mining's social impacts on Aboriginal communities and maintained that monitoring of this dimension is inadequate.[226] FOE argued that 'social impact assessment, consultation and approval processes with traditional owners and affected Aboriginal people is inadequate.'[227]

10.179 In relation to the monitoring of the social impacts outlined above, the GAC's view was that such monitoring was lacking, and that:

> … the limited social impact monitoring that has occurred has been more a process of documenting devastation caused by development, rather than seeking to ameliorate its effects.[228]

10.180 The NLC argued that no specific provision has been made for the ongoing monitoring of the extent to which NT uranium mines have a social impact on Traditional Owners and Indigenous communities.[229]

10.181 To this, the DEH responded that the Aboriginal Project Committee, set up in October 1996 to examine experiences of development in the Kakadu region, had rejected the recommendation of an independent consultant for the ERISS to conduct ongoing social impact assessments.[230]

10.182 The GAC argued that social impact monitoring must be reflected in the regulatory arrangements for the management of uranium mines. It advocates a statutory role to participate in MSTCs, but the NLC rejected this proposal.[231]

10.183 The DEH noted that major social impact consideration was included in the Kakadu Regional Social Impact Study (KRSIS), a project undertaken in 1997 that intended to identify the potential social impact on Aboriginal communities of the Kakadu region being developed.[232] The NLC suggested that, as a first priority, the Australian Government should act

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225 MAPW (WA Branch), *Submission no. 8*, p. 2.

226 See for example: GAC, *op. cit.*, p. 49; Miss Michaela Stubbs (FOE), *Transcript of Evidence*, 19 August 2005, p. 58; ACF, *op. cit.*, p. 21.

227 Miss Michaela Stubbs, *ibid.*

228 GAC, *ibid.*

229 NLC, *op. cit.*, p. 7.

230 DEH, *Submission no. 55.1*, p. 6.

231 GAC, *op. cit.*, p. 57.

232 DEH, *Submission no. 55*, p. 22; Bob Collins, *Kakadu Region Social Impact Study – Community Report*, KRSIS Implementation Team, Darwin, 2000, p. 1, viewed 20 August 2006, <http://www.deh.gov.au/ssd/publications/krsis-reports/impact-study/pubs/krsis-report.pdf>.

on those recommendations of the KRSIS which have not yet received attention of Government.[233]

10.184 The GAC was critical of the KRSIS process, instead calling for a new system for assessing social impact. The GAC argued that social impact monitoring and reporting should be conducted independently, in close consultation with the Traditional Owners.[234]

10.185 The Committee is not clear as to why the KRSIS proposals have not been progressed but has been informed that disengagement by the Traditional Owners may have contributed. The Committee regrets that the GAC chose not to appear before the Committee at its public hearing in Darwin.

10.186 The NLC conceded that services in Jabiru are better because of the presence of the mine, but are still not adequate.[235] However, it was also observed that the KRSIS found that 'whether a mine was next to a large Aboriginal community or 1,000 miles away, most of the social problems were identical.'[236] Similarly, APChem argued that social dysfunction is 'not particular to uranium mining, but is endemic to the mining industry and becomes more noticeable where industrial developments occur in remote areas.'[237]

10.187 For its part, the uranium industry stated that it seeks to ensure local communities benefit from its presence and Australia's three operating mines are subject to extensive assessment.[238] Existing producers recognised that the viability of local communities is dependent on the sustainability of the mines, and therefore seek to:

- respect cultural heritage;
- communicate openly and transparently with local communities;
- support the development of local and regional communities; and
- identify and facilitate employment, training and business opportunities for local communities.[239]

Consultation practices and processes

10.188 A number of submitters were critical of consultation practices and processes adopted by industry and government. For instance, FOE asserted that mining companies unduly pressure Indigenous communities

233 Mr Norman Fry, *op. cit.*, p. 20.
234 GAC, *op. cit.*, pp. 32, 47–9.
235 Mr Norman Fry, *op. cit.*, p. 27.
236 *ibid.*
237 APChem, *loc. cit.*
238 UIC, *Submission no. 12*, p. 44.
239 *ibid.*

and use divisive tactics.[240] However, one submitter replied that 'Aboriginal people have been shamelessly used and abused by the anti-development lobby.'[241]

10.189 The GAC insisted that the key issue with the current process is a lack of a 'sense of control' by the Traditional Owners. The GAC was particularly critical of service provision being dependent on mining activity, and called for service provision and social impact monitoring to be separated from mining activity.[242]

10.190 The GAC was of the view that negotiations should be administered by an independent body and a:

> … comprehensive plan for future engagement in processes should be designed, in consultation with Aboriginal people, and implemented before further development occurs.[243]

10.191 Claims of poor consultation practices were rejected by government and industry, with various examples of proactive and successful consultation being offered by submitters. For example, the DEH noted that Indigenous communities are engaged through the EPBC Act referral, assessment and approval processes:

> Indigenous groups have utilised the EPBC Act public comment processes to comment on referrals and environmental assessments. For example, comments were received from Indigenous groups on the Waste Repository proposal in South Australia. Comments on proposed actions are also received in letters to the Minister.[244]

10.192 Furthermore, the DEH advised that ongoing engagement with Aboriginal communities is facilitated through:

> … Aboriginal representation on the Alligator Rivers Region Advisory and Technical Committees, various Minesite Technical Committees, the Gunlom Land Trust rehabilitation program of the South Alligator Valley legacy mining sites and numerous ad hoc consultations.[245]

10.193 The OSS employs a full-time staff member in Jabiru whose role involves day-to-day communication and engagement with Aboriginal communities, including Traditional Owners.[246] The DEH noted successful

240 FOE, *op. cit.*, p. 16.
241 Name withheld, *Submission no. 25*, p. 1.
242 GAC, *op. cit.*, p. 49, 54.
243 *ibid.*, p. 49.
244 DEH, *Submission no. 55*, p. 21.
245 *ibid.*, p. 22.
246 DEH, *Submission no. 55.1*, p. 6.

Traditional Owner involvement in revising guidelines, and the positive working relationship between the SSD and OSS, and Aboriginal communities:

> The Supervising Scientist Division (SSD) has developed very successful relationships with the Traditional Owners to the extent that some of them now regularly work in the SSD monitoring program. Recently, the Executive Officer of the Gundjeihmi Aboriginal Corporation stated publicly that the Traditional Owners trusted the Supervising Scientist.[247]

10.194 In response to criticisms of the uranium mining industry's—and the minerals industry more generally—alleged history of failure to consult and take Indigenous issues seriously, the MCA argued that whilst this was once an entirely valid criticism, the industry's performance has now dramatically improved:

> I think the criticism of the industry's performance in that area of a decade and a half ago is quite valid … If you had to pick something that has been a paradigm shift in the operations of the Australian minerals industry, I suspect that would be right up the top. We currently have some 350-plus [mainly Indigenous land use] agreements on foot across 200 mining companies … We have not only proclaimed our respect for rights, cultures, interests and special connections to land and waters but also practised and performed it … The memorandum of understanding that we have with the federal government, signed by three ministers, to move beyond corporate Indigenous employment programs to build sustainable communities beyond the life of the mine is a great platform … it will come from local communities identifying needs and expectations in terms of enterprise facilitation, Indigenous employment and the social fabric of society …[248]

10.195 Mr Harry Kenyon-Slaney observed that the relationship between ERA and the Gundjeihmi people has improved markedly in recent years and that the company has 'a very active, ongoing dialogue with the Traditional Owners on a whole range of issues.'[249] As noted above, the company has expressed its desire to work with the Traditional Owners to ensure that a sustainable community remains following the closure of the mine.

247 *ibid.*

248 Mr Mitch Hooke (MCA), *Transcript of Evidence*, 5 September 2005, p. 32

249 Mr Harry Kenyon-Slaney, *op. cit.*, p. 55.

10.196 In relation to the possible eventual development of Jabiluka, Mr Kenyon-Slaney remarked that whilst Jabiluka remains a very valuable asset for the company:

> … it is not going to be developed without the consent of the traditional owners—we are not going to go back to an adversarial, acrimonious environment where we force development on a people who do not want it—and I believe that that is fundamentally the right way to progress. If benefits can be identified that meet everybody's desires then the project will go ahead.[250]

10.197 Heathgate Resources described the successful negotiation and consultation process the company undertook with the Indigenous communities in the Beverley area over a period of some nine months:

> The Beverley mine was the first mine to start in South Australia after the introduction of the native title federal legislation, and some complementary South Australian legislation was also introduced. At the time we were publishing our environmental impact statement and preparing for the construction of the mine, we had four overlapping native title claims over the area of the mine. We were struck with the problem of how to negotiate and achieve agreements with these groups, because without them the mine would not have gone ahead.
>
> … The consultation process we undertook, after a great deal of thought and discussion with legal advisers and others … was a process whereby we worked out what we thought would be an advantageous program of benefits for the Aboriginal people, which was generally modelled on what had happened in the Northern Territory on Aboriginal land as distinct from native title claimed land.
>
> We called and held … the largest meeting of the Adnyamathanha and Kuyani people ever held in the Flinders Ranges area. There were about 400 people present, and we presented the program to them. The meeting was held under the adjudication of the local member of parliament. We presented an offer and then we proceeded over subsequent months to negotiate with the parties involved.[251]

10.198 The essential components of the agreement include:

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250 *ibid.*, p. 56.

251 Mr David Brunt (Heathgate Resources), *Transcript of Evidence*, 19 August 2005, p. 99.

> … royalties to the Aboriginal people, the Adnyamathanha people and to each of the claim groups … There are undertakings in respect of employment. Our target is 20 per cent of the site work force and … we are currently at 25 per cent. There are some other undertakings in respect of contracts for the supply of goods and services for the mine. It was, in many respects, a groundbreaking exercise in South Australia …[252]

10.199 Currently, BHP Billiton has an agreement in place with three Aboriginal claimant groups and these were negotiated at the time of the most recent expansion of the mine in the late 1990s. The agreement deals with how heritage issues are managed. BHP Billiton noted that during those negotiations the company provided the claimants with resources to fund their administrative needs. Annual funding continues to be provided to the groups as an element of the agreement.[253]

10.200 For the proposed expansion of Olympic Dam, BHP Billiton noted that the company is currently in negotiations with the three native title claimants, none of whom live in the area of the mine. The company reported that it has signed terms of reference for discussions with the claimants and expects negotiations to be successfully concluded within a year. Mr Richard Yeeles of BHP Billiton explained that:

> In fact, we had all the groups up in Olympic Dam a couple of weeks ago with their legal advisers. They wanted an understanding of where this open pit would go and the sort of impact it would have on the land. We showed them that. We showed them where the waste rock dump may go. I must say, the negotiations so far have been conducted in a very cooperative spirit. The groups are obviously interested in the benefits that may be available to their communities from what we would hope to finalise as an Indigenous land use agreement. We are very optimistic that over the next 12 months we will be able to put something in place which will deliver what we need in terms of land access, and also give to the community some sustainable benefits in terms of training and employment programs and other benefits.[254]

10.201 Jindalee Resources, owners of the Bigrlyi uranium deposit in the NT, also mentioned the importance of the involvement and support of the local Indigenous community to the viability of the company's project:

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252 *ibid.*, p. 100.

253 Mr Richard Yeeles (BHP Billiton Ltd), *Transcript of Evidence*, 2 November 2005, pp. 18.

254 *ibid.*, p. 17.

> The local Aboriginal community is a shareholder in the Bigrlyi uranium mine in the Northern Territory, which we will hopefully bring on in a couple of years time. They have quite a significant chunk of it and they are already doing a bit of contracting for us. This is part of getting the community involved, and those people are enormously on-side.[255]

10.202 Summit Resources, which is currently prevented from mining its uranium deposits in Queensland, stated that it has the complete support of the Traditional Owners—the Kalkadoon and Walwuwarra Peoples:

> We have the traditional owners supporting us at Mt Isa. We have resolved all the native title claim matters with them and we are able to get on with our work.[256]

10.203 Moreover, Summit explained that the Kalkadoon People supply the company with some equipment for its exploration activities. The agreements the company has in place with the Traditional Owners provides the opportunity for the Aboriginal people to provide the company with services and workers.[257]

10.204 Junior uranium exploration companies also expressed a keenness to work with and to support Indigenous communities. Nova Energy, owners of the Lake Way and Centipede deposits in WA commented that:

> I think the big opportunity that presents itself is probably to have a greater engagement from the Aboriginal community at Wiluna. We have worked a great deal towards encouraging the development of Indigenous businesses. We assist the community in many ways: we put money into trust funds for the community, we part-fund doctors, we help the local school. But all of this is quite challenging in the current gold price environment, because margins are very thin in Australian goldmining these days. A business such as this—a new business that has very high margins—would have much greater capacity for assisting with community development from day one.[258]

10.205 In relation to capacity, there was some question as to whether Traditional Owners have the educational background to effectively engage in consultation and negotiations.[259] The role of the Land Councils was also noted, and there was some suggestion that these bodies may not, in all

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255 Mr Donald Kennedy (Jindalee Resources Ltd), *Transcript of Evidence*, 23 September 2005, p. 58.

256 Mr Alan Eggers (Summit Resources Ltd), *Transcript of Evidence*, 3 November 2005, p. 6.

257 *ibid.*, p. 11.

258 Dr Timothy Sugden (Nova Energy Ltd), *Transcript of Evidence*, 23 September 2005, p. 80.

259 Mr James Pratt (Deep Yellow Ltd), *Transcript of Evidence*, 23 September 2005, pp. 84–85.

cases, be constructive in facilitating clear communication between mining companies and the Traditional Owners.[260]

Employment and training opportunities

10.206 The Committee received evidence in relation to employment and training opportunities available to Indigenous communities. The following section provides some background on current employment and training initiatives, details some criticisms relating to perceived inadequacies of such initiatives, and outlines industry's response.

10.207 In general, mining companies and exploration companies expressed a strong interest in providing employment for Aboriginal people at mine sites. For instance, as a junior exploration company with interests in the NT, Compass Resources indicated its intention to work with the NLC and the local Indigenous communities to provide employment opportunities for the Aboriginal people in the area of its proposed developments.[261]

10.208 In relation to Indigenous employment at Olympic Dam, BHP Billiton reported that the company has two initiatives: Aboriginal people from the claimant groups are employed at the mine, although not in large numbers, and these people commute from Whyalla; and the company conducts 'job readiness' programs:

> We bring people in to the site, run them through training programs so that they have tickets to operate heavy equipment—to operate a forklift or a crane—and are therefore available. If they choose to apply for jobs, they are then qualified to apply for them. We put a lot more people through the job readiness programs than actually come back and apply for jobs, but we do have a program to make sure people are in a position to compete in the market for jobs.[262]

10.209 Heathgate Resources explained that the company's success in achieving 25 per cent employment for Aboriginal people at the Beverley mine site was due, firstly, to a real commitment by the company to achieve an Indigenous employment outcome. Heathgate also explained that the company initiated a program whereby two Aboriginal liaison officers report directly to the General Manager on matters affecting Aboriginal people in order to ensure that these issues are addressed quickly. In addition, the company conducts quarterly meetings with claimants to allow the Aboriginal communities to communicate issues of concern to the

260 *ibid.*

261 Dr Malcolm Humphreys, *op. cit.*, p. 66.

262 Mr Richard Yeeles, *op. cit.*, p. 18.

company and for Heathgate to update the communities on the company's activities. Heathgate also claimed to have made a substantial investment in training.[263]

10.210 Heathgate Resources explained that the company perceives that the issue of greatest concern to Aboriginal people in the area of the Beverley mine is employment, not royalties:

> When we have meetings with the Aboriginal community, they want to know what the employment numbers are. We get more credibility from the Aboriginal people when we can say that we are not 20 per cent, we are 25 per cent. If we are at 25 per cent, we are going to try to go to 30 per cent and to 35 per cent. We are not going to stop at 25 per cent.[264]

10.211 However, in the NT, the NLC was critical of the allegedly 'glaring failures' of ERA in the lack of employment opportunities for Aboriginal people in the area, with few of the Aborigines employed at Ranger coming from the local Mirrar people.[265] However, the NTMC noted that of a total staff of 300, ERA employs some 45 Aboriginal people at its operations and noted that:

> There have been difficulties in employing local Aboriginal people because the traditional owners in that area did not approve of their people working at the mine and they expressed discomfort with other Aboriginal people coming in from outside the area. However, the company is engaged in discussions with the local people on these issues, and those discussions are ongoing.[266]

10.212 Mr Harry Kenyon-Slaney noted that ERA is actively involved in a range of employment, educational and social programs for the community in the vicinity of the Ranger mine:

> The broader work that we do in the community is very significant. We are actively involved with the local traditional owners on a range of social programs. We have been working with them on a youth centre, Aboriginal employment opportunities and trying to improve opportunities for schooling at years 11 and 12. There are programs in respect of alcohol and management. We work on the ground in the community on these issues constantly, and have done for many years. These are difficult issues that have no

263 Mr Mark Chalmers, *op. cit.*, p. 100.

264 *ibid.*, p. 102.

265 Mr Norman Fry, *op. cit.*, p. 20.

266 Ms Kezia Purick, *op. cit.*, pp. 32–33.

> immediate solution but they require everyone to participate. We try to do that very actively.[267]

10.213 The ERA *Social and Environmental Report 2005* identifies a real increase in the number of Aboriginal employees in the company, and communicates the company's undertaking to give greater focus to providing more employment and training opportunities to Aboriginal communities:

> The Aboriginal participation rate in the company was 13 per cent, an increase from 10.5 per cent at the end of 2004, but also reflecting higher numbers of overall ERA permanent and fixed-term employees (2005: 305; 2004: 277; 2003: 238). ERA has announced it will make increased Aboriginal employment and training a key objective in 2006.[268]

10.214 Notwithstanding this marginal improvement, the NLC claimed that such poor outcomes for Aboriginal employment and training must not continue, particularly given successes with Indigenous populations in other parts of Australia and overseas.[269] For instance:

> … Queensland Mines employed over 200 local Aboriginal people (out of a population of around 800) at Nabarlek between 1980 and 1987 …[270]

10.215 Mr Jerry Grandey, President of Cameco Corporation, which mines uranium in the Canadian province of Saskatchewan, stated that 80 per cent of the company's 1 500 employees in the northern part of the province are of Aboriginal descent and 60 per cent are residents of the north. Cameco argued that a key to its success in winning public support for uranium mining has been its efforts at working with Aboriginal people:

> … the issues about aboriginal employment, bringing on aboriginal business, creating trucking and mining consultations and catering, and expertise and infrastructure within the aboriginal community are things that we have been working on over the course of about 20 years.[271]

10.216 Cameco has implemented a number of different strategies to increase Aboriginal employment and training in Saskatchewan, including:

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267 Mr Harry Kenyon-Slaney, *op. cit.*, p. 55.

268 ERA, *Social and Environmental Report 2005*, ERA, Darwin, 2005, p. 10, viewed 7 August 2006 <http://www.energyres.com.au/corporate/ERA_SE_Rep05ART.pdf>.

269 NLC, *op. cit.*, p. 8.

270 *ibid.*

271 Mr Jerry Grandey (Cameco Corporation), *Transcript of Evidence*, 11 August 2005, p. 2.

- a range of economic, social and community relations programs that are designed to ensure that the company's activities are undertaken in an inclusive, sensitive and socially appropriate way;[272]
- a special training agreement with industry partners, indigenous community representatives, and federal and provincial governments, resulting in hundreds of aboriginal northerners being trained for employment in the mining industry;[273]
- supporting post-secondary scholarships, education awards programs, northern summer student employment, science camps, site tours and career counselling;[274]
- working with teachers and curriculum developers to facilitate the integration of maths and science programs in local schools;[275] and
- supporting a business program to encourage the development of aboriginal businesses used by the mining operation.

10.217 This last initiative, of supporting Indigenous businesses used by the mining operation, has resulted in over 70 per cent of Cameco's contracted services being provided by 16 local suppliers, 10 of which are majority owned by aboriginal people.[276]

10.218 Several submitters highlighted impediments to higher rates of Aboriginal employment in the uranium industry, including low educational attainment and geographical isolation. For instance, BHP Billiton noted that a barrier to employment for Aboriginal people at Olympic Dam is the remoteness of the mine and the decision of many not to live at Roxby Downs.

10.219 The NTMC also observed that mining companies operating in the Territory often want to employ more Aboriginal people, but one of the main impediments to doing so is poor literacy and numeracy among Aboriginal people:

> Companies embark on their own bridging programs to get the young adults up to a level of literacy and numeracy such that they can work on a mine site in any capacity. The most obvious component is safety: you must be able to read the safety signs and everything that goes with the safety regime of a mine site. Yes, it is a problem, but the companies are always trying to address that

272 Cameco Corporation, *Exhibit no. 69*, *Speech presented by Mr Jamie McIntyre*, p. 3; Cameco Corporation, *Exhibit no. 70*, *Speech presented by Chief Harry Cook*, p. 19.

273 Cameco Corporation, *Exhibit no. 69*, *ibid.*, p. 4; Cameco Corporation, *Exhibit no. 70*, *ibid.*, p. 14.

274 Cameco Corporation, *Exhibit no. 69*, *ibid.*

275 *ibid.*

276 *ibid.*, p. 5; Cameco Corporation, *Exhibit no. 70*, *op. cit.*, p. 9.

> issue in order to get more employment opportunities for the local Aboriginal people.[277]

10.220 Low educational attainment also impacts on the capacity of Indigenous peoples to take advantage of employment opportunities in the uranium industry. The importance of education was demonstrated by Cameco's success with aboriginal employment in Canada:

> In Canada there has been a very long period of effort towards education in the communities: of making sure that you had maths, science and some engineering introduced to the stage of the school curriculum where you could capture junior high and high school level students and of giving them opportunities and scholarships, of public education programs and of community involvement.[278]

10.221 For their part, the NLC readily conceded that literacy and numeracy is an important issue, and called for equitable funding for education in remote Aboriginal communities.[279]

10.222 Despite these challenges, the NLC noted previous examples of successful mining operations which facilitated increased employment and training opportunities for Aboriginal communities. It therefore called for enforceable employment targets, employment and training clauses in mining agreements, and the introduction of Indigenous business support and tax incentives similar to those in place in Saskatchewan.[280]

10.223 The NTMC, however, observed that the situation in the NT is 'quite different' from Cameco's successes in providing employment for Indigenous people. Whilst Australia should strive to achieve the Canadian outcomes, the NTMC warned against setting specific targets:

> I think we should strive to work very closely with the land council and the traditional owners to improve that, but not on a target driven basis, particularly where there are potential penalties. I think the thing to bear in mind is that it has taken us a long time in Canada to achieve those results, and unfortunately it is going to take a long time here. The industry has to strive to get to that point if it can.[281]

10.224 In relation to the inclusion of employment and training clauses in mining leases, the NTMC responded that these are 'standard in all agreements.

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277 Ms Kezia Purick, *op. cit.*, p. 44.

278 Mr Jerry Grandey, *op. cit.*, p. 6.

279 Mr John Daly (NLC), *Transcript of Evidence*, 24 October 2005, p. 26; Mr Norman Fry, *op. cit.*, p. 29.

280 NLC, *op. cit.*, p. 9.

281 Dr Ron Matthews (NTMC), *Transcript of Evidence*, 24 October 2005, p. 44.

Whether they are native title agreements or land rights agreements, there are always provisions for employment and training.'[282]

10.225 The Committee recognises some of the complexities associated with these issues, not the least of which is the opposition to Ranger's continued operation by the Traditional Owners. This in turn makes it difficult for the company to provide employment if the local Aboriginal people are effectively barred from seeking employment with the company. The Committee is sympathetic to the position in which the company finds itself in this respect.

10.226 The Committee is very pleased to note the success that Heathgate Resources has achieved in its employment of Aboriginal people at its Beverley operation in SA. The Committee notes that this outcome was achieved through the company's commitment to increasing Aboriginal employment and its implementation of a number of specific initiatives, including the employment of Aboriginal liaison officers with direct access to management, and an investment in training.[283]

10.227 The Committee hopes that Heathgate Resources' success in Aboriginal employment can be emulated by other companies so that the benefits of mining can be enjoyed by greater numbers of Aboriginal people and their communities nationwide.

10.228 The Committee believes that strategies should be developed to improve industry's training and employment outcomes at uranium mines in Australia, with consideration given to studying and, if possible, emulating Cameco's experience in Saskatchewan. The Committee is conscious of the observation by industry and Cameco itself that the success in Saskatchewan took decades to achieve. Nonetheless, the Committee believes that industry, Aboriginal communities and governments should strive to achieve similar outcomes in Australia.

282 Mr Neville Henwood (NTMC), *Transcript of Evidence*, 24 October 2005, p. 43.

283 Mr Mark Chalmers, *op. cit.*, p. 100.

Recommendation 7

The Committee recommends that the Australian Government work with industry, Indigenous groups and state/territory governments to develop strategies to improve Indigenous training and employment outcomes at uranium mines, with consideration given to studying and, if possible, emulating the strategies employed by Cameco Corporation and governments in Canada. The Committee further recommends that, where appropriate, mining companies consider employing Aboriginal liaison officers with direct access to management.

To ensure adequate local community consultation, the Committee further recommends that a process be established whereby it and its successor committees be formally given access to new uranium mine sites, with customary powers of inquiry and report to the Parliament. This process should formally provide for affected local governments to nominate a person to liaise with the Committee about any community concerns.

Aboriginal Land Rights Act

10.229 The NLC drew the Committee's attention to the Canadian model of joint ventures between mining companies and Indigenous businesses. Again, the NLC emphasised that:

> … we want all of the constraints to really getting us to the table of commercial reality removed from the Land Rights Act so that we can really play on the same landscape as everybody else.[284]

10.230 When asked whether it agreed with the opposition to new uranium mines by the NT Government, the NLC responded:

> Utterly not … That is quite a silly situation for government to get itself into, and the only losers in this are traditional owners and mining companies in the Australian and Territory economies.[285]

10.231 In terms of increasing the social dividend for Aboriginal people in the NT, the NLC argued that mining agreements be commercially defined and of a commercial nature. To achieve this, the NLC called for the amendments to part four of the *Aboriginal Land Rights Act* (ALRA), previously agreed to by the four land councils and the NT Government, to be enacted in the

284 Mr Norman Fry, *op. cit.*, p. 22.
285 *ibid.*, p. 21.

Federal Parliament.[286] The NLC claimed that the large mining companies support this approach.[287]

10.232 While noting that there have been no new mines developed on Aboriginal land in the NLC area since the ALRA was introduced, the NTMC noted that the NLC has a 'very commercial focus' and that 'it is easier to get things done.'[288] However, the NTMC rejected the argument by the Land Council that amendments are required to part four of the ALRA in order facilitate mining agreements:

> Contrary, perhaps, to what Mr Fry said earlier, there is not really a need to change part 4 to facilitate agreements being reached, or to facilitate any terms of those agreements. I do not think the proposed package of reforms that has been put by the land councils or the Northern Territory government does much more than fiddle around the edges. At a fundamental level, the Minerals Council would prefer that the exercise of the veto was up the front rather than at the back end of negotiation, but that is something that we have agreed to disagree on.[289]

10.233 In addition to seeing the Aboriginal right of veto exercised up front, the NTMC also argued that the division of royalty monies be adjusted so that the monies that currently go to the Aboriginal Benefits Reserve (30 per cent of the total) are instead allocated to the Traditional Owners and others directly affected by mining operations. In this way, the Traditional Owners would receive 60 per cent of royalty monies, with the remaining 40 per cent continuing to be split between the Land Councils.[290]

10.234 The Committee notes the intention of the Australian Government to introduce changes to the ALRA so as to improve the workability of the legislation for the benefits of mining companies and traditional land owners. [291]

286 *ibid.*, p. 20; NLC, *Submission no. 78.1*, p. 4.
287 Mr Norman Fry, *ibid.*, p. 28.
288 Mr Neville Henwood, *op. cit.*, p. 37.
289 *ibid.*, p. 38.
290 *ibid.*, p. 41.
291 NLC, *Transcript of Evidence*, 24 October 2005, pp. 20-29.

Conclusions

Regulation

10.235 While the regulation of uranium mining is principally a state and territory government responsibility, the Australian Government's interests and responsibilities in this area include:

- environmental assessment and approval of new uranium mines and significant expansion of existing mines;
- ownership of uranium in the NT; and
- oversight of uranium mining operations in the ARR of the NT through the SSD.

10.236 Criticisms of existing regulatory arrangements were largely directed to the adequacy of provisions for environmental protection from the impacts of uranium mining in the Kakadu National Park and the ARR. Criticisms were also made of the performance of the OSS which, among a number of allegations, was said to have been 'captured' by ERA. The OSS provided convincing rebuttals to each of these allegations, as well as to arguments relating to the adequacy of tailings and water management at Ranger.

10.237 The Committee rejects the claim that the regulation of uranium mining in the ARR is inadequate. The owners of the Ranger mine meet some of the most rigorous reporting regimes in Australia and there is extensive formal oversight of its operations. The Ranger operation is monitored and regulated by a range of independent bodies including Australian Government agencies (OSS, DITR and ASNO), NT Government agencies (particularly DPIFM), and independent review bodies, namely the MSTCs, ARRTC and ARRAC.

10.238 Moreover, the Committee notes that monitoring and research by the OSS since 1978 has concluded that uranium mining operations at Ranger have had *no* detrimental impact on the Kakadu National Park. This confirms that the regulatory regime governing uranium mining in the ARR has indeed succeeded in protecting the environment from any harmful impacts caused by uranium mining.

10.239 Uranium mining regulation in the ARR has, however, evolved into what appears to be an unduly complex regime, comprised of arrangements underpinned by a range of Commonwealth and Territory legislation. The Committee recognises that the complexity may well have been unavoidable because of the combination of factors, including that: mining is taking place on Aboriginal land; the need to protect the Kakadu National Park; and the special nature of uranium. Nonetheless, if a regulatory framework were to be designed from 'scratch' in 2006, it seems unlikely that a similar framework would be developed. The Committee will not recommend specific improvements but suggests that the entire regulatory regime in the NT should be reviewed with a view to consolidation and simplification.

10.240 The Committee notes the GAC's recommendation to consolidate the provisions of the 17 November 2000 Agreement, the Working Arrangements, Part III of the Commonwealth *Atomic Energy Act 1953* and the EPARR Act in order to clarify the responsibilities of the governments and agencies involved in uranium mining activities. The Committee considers that the merits of this proposal should be considered as part of the comprehensive review of NT uranium mining regulation suggested above.

10.241 The Committee recommends that consideration should be given to utilising the expertise of the OSS in assessment and approvals processes for uranium mines generally. Mindful that industry wishes to see any unnecessary duplication across levels of government eliminated, the Committee urges that an expanded role for the OSS not add to what is already a highly regulated industry.

10.242 Groups critical of uranium mining argued that environmental and health oversight functions are not clearly or adequately separated from industry promotion functions in SA and the NT, or indeed at the Federal level. The NT Government stated that following a recent regulatory review, new mechanisms have now been put in place to ensure industry development and regulatory functions are kept separate. No submission was received from the SA Government.

10.243 The Committee is not in a position to judge the veracity of these claims but believes that industry promotion and regulatory/environmental impact assessment functions ought to be clearly separated at all levels of government. The Committee urges the Australian Government to examine this issue and, where necessary, to encourage state governments to rectify any agency-based conflicts of interest and to clearly separate industry promotion and regulatory functions.

10.244 Although the Committee believes there have been clear improvements in environmental regulations relating to mine closure and rehabilitation, some partially rehabilitated former mines continue to present pollution problems. The Australian Government's recent decision to allocate some additional funding to address this problem is welcome, but the Committee recommends that the Australian Government redouble efforts to completely rehabilitate former uranium mines in the ARR and elsewhere.

Aboriginal communities

10.245 Despite professing concern that Indigenous groups be consulted, environmental groups revealed that, should Traditional Owners approve a mining development, they would still oppose uranium mining. This seems to support the observation made by one submitter who remarked that Aboriginal groups are being used by some 'no development' groups to support their opposition to uranium mining. Traditional Owners' views are clearly *not* to be respected if they happen to support resource development.

10.246 Notwithstanding this, care must be taken to ensure that uranium mining does not impact negatively on local Aboriginal communities. The Committee is of the view that the social impacts of mining operations must be adequately monitored, and Aboriginal communities and Traditional Owners should have an opportunity to share in the benefits associated with a vibrant minerals industry.

10.247 The Committee is not convinced that social problems are peculiar to uranium mining, or to Jabiru, Ranger and ERA, but rather that the social problems and issues of service provision in Jabiru are common to large Aboriginal communities wherever they are located.

10.248 In relation to employment, the Committee notes impediments to increasing Aboriginal engagement in the uranium industry, including the opposition by some Aboriginal groups and low levels of educational attainment. The Committee sees merit, however, in industry seeking to emulate the examples of mining operations that have succeeded in achieving benefits for Indigenous communities. In particular, the Committee was impressed by the successes of Heathgate Resources at Beverley and Cameco Corporation in Saskatchewan. The Committee strongly urges industry, governments and Indigenous communities themselves to continue to strive to ensure Aboriginal people benefit from uranium mining operations through employment, business and training opportunities.

11

Impediments to the uranium industry's development

For more than three decades, the Australian community has been assailed with false perceptions of danger or high risk emotively linked with such words as radiation, research reactor and uranium. In the absence of sound education and informed realism, some will react to this with fear and anger.[1]

For too long Australia's attitudes and policies governing uranium mining and the nuclear fuel cycle have been based on misconceptions, ignorance, and the occasional deliberate lie. The result has been unjustifiable restrictions on the development of new mines, which confers privilege on existing operations, and the perpetuation of negative attitudes towards nuclear power which, if not reversed, may see Australia fail to play its potentially major role in the supply of nuclear fuel to a successful, and expanding, world nuclear electricity industry.[2]

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1 Professor Leslie Kemeny, *Exhibit no. 9, Power to the people*, p. 3.

2 Paladin Resources Ltd, *Submission no. 47*, p. 2.

Key messages —

- **The key impediment to the growth of the uranium industry in Australia remains the prohibition on uranium mining in some states and the lack of alignment between federal and state policy.**
- **The restrictions on uranium mining are illogical, inconsistent and anticompetitive. Restrictions have impeded investment in the industry, and have resulted in a loss of regional employment and wealth creation opportunities, royalties and tax receipts. The only beneficiaries of restrictions are the three existing producers and foreign competitors.**
- **State policies that prevent development of new uranium mines should be lifted and legislative restrictions on uranium mining and exploration should be repealed.**
- **While widespread misconceptions about uranium mining and nuclear power persist, the industry's growth will be impeded. It is vital that the public's concerns be responded to. Information should be communicated both to the general public and opinion leaders that eases concerns and addresses areas of poor understanding.**

Introduction

11.1 In conducting the present case study, the Committee received extensive evidence from stakeholders in the uranium industry, outlining a range of impediments to the industry's development in Australia. This chapter discusses the most substantial of these impediments and, where appropriate, outlines the Committee's recommendations for addressing them.

11.2 Impediments to the industry's growth in Australia can be broadly categorised as follows:

- general impediments to the industry;
- impediments to existing producers;
- impediments to junior exploration companies; and
- public perceptions of the uranium industry and nuclear power.

11.3 General impediments to the industry have the potential to affect all uranium exploration and mining companies, irrespective of the size of the company or scope of its operations. These general impediments are of concern both to existing producers and junior exploration companies. The impediments identified in this category include:

- restrictions on uranium mining and exploration;
- regulatory inconsistencies across jurisdictions;
- lack of government assistance; and
- sovereign risk.

11.4 Impediments to existing producers are those concerns that were cited exclusively by existing producers. In this context, existing producers or 'majors' are considered companies presently producing uranium and with a market capitalisation exceeding $200 million.[3] Impediments identified by existing producers include:

- government scrutiny of sales contracts;
- transportation;
- labour and skills shortages; and
- excessive reporting requirements.

11.5 Similarly, impediments to junior exploration companies are those cited exclusively by junior exploration companies. In this context, the phrase 'junior exploration company' refers to any small uranium exploration company not currently producing uranium, or whose market capitalisation falls below $200 million.[4] Impediments within this category include:

- absence of infrastructure in some prospective mining areas;
- labour and skills shortages;
- geoscientific data;
- access to capital; and
- opposing influence of other industries.

11.6 Finally, negative public perceptions of the uranium industry and issues associated with communicating information were frequently cited, both

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3 House of Representatives Standing Committee on Industry and Resources (HRSCIR), *Exploring: Australia's Future*, Parliament of Australia, Canberra, 2003, p. 21. Available online: <http://www.aph.gov.au/house/committee/isr/resexp/chapter3.pdf>.

4 *ibid*.

by existing producers and by junior exploration companies, as key impediments to the industry's growth in Australia. Notwithstanding that this matter falls within the 'general impediments' category, its importance dictates more extensive treatment in a separate section of this chapter.

General impediments to the industry

Restrictions on uranium mining and exploration

> *Over the past 30 years or so, Australia has been viewed as largely politically unstable in terms of supporting a sustainable uranium industry and this needs to change.*[5]
>
> *The lack of alignment between State and Federal policies is the greatest impediment to the industry's development.*[6]

11.7 The Committee received extensive evidence that the prohibition on uranium mining, and in some cases also uranium exploration, by some state governments has been the single greatest impediment to the industry's growth in Australia. It is argued that this has resulted in an underdeveloped uranium industry, missed opportunities, and undesirable inconsistencies between jurisdictions. This section provides a brief background to the present restrictions on uranium mining and exploration, summarises the criticisms of these restrictions and their negative impacts, and suggests a way forward.

Background

11.8 In 1984, the newly elected Australian Labor Party (ALP) Federal Government introduced the so-called 'three mines policy'. This policy nominated Ranger, Nabarlek and Olympic Dam as the only projects from which uranium exports would be permitted. These three mines (Nabarlek ceased processing stockpiled ore in 1988) are located in the Northern Territory (NT) and in South Australia (SA).

11.9 The 'three mines policy' was discontinued by the Commonwealth with the change of Government in 1996. However, the policy persists at the state government level, with uranium mining permitted only at the existing facilities in SA (from Olympic Dam, Beverley and Honeymoon) and the

5 Heathgate Resources Pty Ltd, *Submission no. 49*, p. 2.

6 Nova Energy Ltd, *Submission no. 50*, p. 25.

NT (from Ranger).[7] Hence, uranium resources in Western Australia (WA) and Queensland cannot currently be developed because these governments will not grant mining leases for the purpose of mining uranium. Uncertainty as to whether new uranium mines could be opened in the NT was resolved by an announcement of the Australian Government in August 2005 that it would assume responsibility for approving new mines. This reflects the Australian Government's powers over uranium mining in the Territory contained in the *Atomic Energy Act 1953*. However, during the period that the 'three mines policy' prevailed market conditions (i.e. low uranium prices) were also not conducive to the opening of new mines.

11.10 The basis and extent of restrictions varies across the states. In Queensland and WA the state governments have announced that, as a matter of policy, they will not permit uranium to be mined. However, in these states it is possible for companies to explore for uranium. In contrast, during the 1980s Victorian and New South Wales (NSW) governments legislated to explicitly prohibit both uranium mining and exploration for uranium.[8] The WA Government has also foreshadowed legislative restrictions.[9]

The cost of restrictions on uranium mining and exploration

11.11 Throughout the Committee's inquiry, prohibitions on uranium mining were consistently cited as one of the greatest impediments to the industry's development. For example, the Uranium Information Centre (UIC), claimed that:

> … the current anti-uranium stance of several states clearly hinders the exploration for and development of uranium resources, as does a lack of bipartisan support at federal level.[10]

11.12 Summit Resources submitted that the state government restrictions result in:

> … the lack of investment in uranium exploration, limited competition, loss of employment and wealth creation opportunities in other areas and States of Australia and a loss of a

7 ALP, *National Platform and Constitution 2004*, section 68, viewed 27 April 2006, <http://www.alp.org.au/download/now/platform_2004.pdf>.

8 See, for example: Minerals Council of Australia (MCA), *Submission no. 36*, pp. 2–3; Geoscience Australia (GA), *Submission no. 42*, pp. 17–18. In Victoria the prohibitions on exploring for and mining uranium and thorium are contained in section five of the *Nuclear Activities (Prohibitions) Act 1983*. In NSW, the prohibitions on prospecting for or mining uranium are contained in section three of the *Uranium Mining and Nuclear Facilities (Prohibitions) Act 1986*.

9 Association of Mining and Exploration Companies, *Submission no. 20*, p. 2.

10 UIC, *Submission no. 12*, p. 17.

> major contribution to Australia's economic well being without delivering any benefits.[11]

11.13 Not only are restrictions on uranium exploration and mining an incidental hindrance to the industry's development, but it has been claimed that these prohibitions are deliberately constructed to ensure the stagnation of the industry. As Compass Resources observed:

> The current structure of the uranium industry has been formulated in an environment where there has been a deliberate restriction placed on development.[12]

Missed opportunities

11.14 It was submitted that the cost of uranium mine restrictions includes missed opportunities for Australia, and for certain states and territories in particular. These missed opportunities take the form of benefits of uranium mining, which are not able to be realised to their full extent, and they include:

- economic benefits for the nation and individual states and territories, through:
  - ⇒ direct and indirect employment;
  - ⇒ investment in exploration, equipment and new technologies;
  - ⇒ foreign investment in Australian operations;
  - ⇒ contributions to Australia's balance of payment figures;
  - ⇒ export earnings, also potentially off-setting negative impacts on Australia's coal exports of any international move to reduce global carbon emissions;
  - ⇒ long-term revenue sources, via royalty payments to state governments;
  - ⇒ payroll, consumption, company and personal taxes paid to state and federal governments;
  - ⇒ enhanced general economic activity and flow-on benefits;
- significant contributions to regional economies, through:
  - ⇒ improved infrastructure, including infrastructure related to communications, transport (access roads and railways), water supply and sport and recreational facilities;
  - ⇒ community and social infrastructure, particularly due to population increases in surrounding areas;

11 Summit Resources Ltd, *Submission no. 15*, p. 4.

12 Compass Resources NL, *Submission no. 6*, p. 3.

- ⇒ increased housing;
- ⇒ large-scale construction projects;
- ⇒ health monitoring of local employees;
- ⇒ training and education opportunities;
- ⇒ local employment and business opportunities;

- environmental benefits:
  - ⇒ Australia could, through supplying uranium, contribute to reduced greenhouse gas emissions worldwide, as discussed in chapter four;
- benefits for Aboriginal groups and traditional owners, through:
  - ⇒ royalty and other payments;
  - ⇒ direct and indirect employment;
  - ⇒ business opportunities supporting the uranium industry;
  - ⇒ enhancing the capacity of Indigenous Australians to more effectively engage in the broader economy;
  - ⇒ cross-cultural training and awareness provided to non-Indigenous mineral company employees; and
- increased opportunities for Australian resource companies.[13]

11.15 The Australian Nuclear Science and Technology Organisation (ANSTO) noted that mining restrictions prevented Australia from realising the benefits of developing uranium resources summarised above:

> … current policy in some states precludes the development of new mines from known resources, and other states have legislation that prohibits the prospecting for, or the mining of, uranium. It is therefore possible that Australia will not be able to maximise the benefits that could be obtained from its uranium resources.[14]

Lost market share

11.16 Southern Gold noted that, as a result of restrictions on uranium mining and exploration, Australia has lost its advantage over competing uranium-producing countries:

13 Jindalee Resources Ltd, *Submission no. 31*, pp. 2, 4; Arafura Resources NL, *Submission no. 22*, p. 8; Mr Michael Fewster (Eaglefield Holdings Pty Ltd), *Transcript of Evidence*, 23 September 2005, p. 24; Eaglefield Holdings Pty Ltd, *Submission no. 18*, pp. 2, 5; Compass Resources NL, *op. cit.*, pp. 2, 4; UIC, *op. cit.*, pp. 6, 8, 12, 13; Summit Resources Ltd, *op. cit.. 15*, pp. 3, 33; AMEC, *Submission no. 20*, p. 4; MCA, *op. cit.*, p. 14; Areva Group, *Submission no. 39*, pp. 14–15; ERA, *Submission no. 46*, pp. 1–2; Heathgate Resources Pty Ltd, *op. cit.*, p. 3; Nova Energy Ltd, *op. cit.*, pp. 11–13, 20; Southern Gold Ltd, *Submission no. 54*, pp. 6–9, 11.

14 ANSTO, *Submission no. 29*, p. 5. See also: UIC, *op. cit.*, p. 8.

> With the effective moratorium on uranium exploration over the past 30 years, Australia has lost an economic and strategic opportunity to use its dominant resource position to become the leading supplier, researcher and manager of uranium resources.[15]

11.17 The Association of Mining and Exploration Companies (AMEC) argued that overseas uranium producers are the chief beneficiaries of Australia's uranium restrictions, with current restrictions on uranium mining and exploration essentially constraining:

> … the readiness of people to invest in Australia's uranium exploration and mining and thereby effectively consolidates Canada's current advantage as the leading world producer of uranium.[16]

11.18 Mining restrictions have also meant that Australia's uranium exports are lower than they potentially could be and that the nation has lost market share to Canada. The Minerals Council of Australia (MCA) noted that:

> Canada exports more uranium than Australia to world markets even though it has only 17 per cent of the world's Economic Demonstrated Resource (EDR) compared to 39 per cent for Australia. The reason is simply explained. It is due to the fact that Canada does not have a restriction on the number of uranium mines that are permitted to operate.[17]

11.19 Similarly, the Northern Territory Minerals Council (NTMC) observed that Australia had so far failed to realise its full potential as an exporter of uranium:

> In the 1970s, Australia had a large competitive edge over Canada, which has now been surrendered. Canada … currently has a position of dominance. Development of new uranium deposits … would help Australia rapidly retrieve the lost ground …[18]

11.20 Illustrating the importance of government support for a well-functioning uranium industry, AMEC compared the situation in Australia with that in Canada:

> Australia's major competitor is Canada, which produces significantly more uranium than Australia and is strongly

15 Southern Gold Ltd, *op. cit.*, p. 2.

16 AMEC, *op. cit.*, p. 3.

17 MCA, *op. cit.*, p. 9.

18 NTMC, *Submission no. 51*, p. 2.

> expanding its capacity, facilitated by favourable government policy and operating conditions.[19]

11.21 Geoscience Australia advised that restrictions on uranium mining in Australia had resulted in some international unease, including within the Uranium Group, about the security of medium- to long-term supplies of uranium.[20]

11.22 Compass Resources further warned that the continued restriction of the uranium industry's development in Australia could result in Australian companies pursuing uranium projects offshore.[21]

11.23 The UIC also argued that the volatility of uranium mining policy in Australia had deterred substantial foreign investment in the industry.

> ... foreign investment for new mines … particularly from North American and European financial markets, has been deterred by concern that public policy may restrict production.[22]

Exploration investment

11.24 The Committee received substantial evidence that restrictions on uranium mining had adversely affected exploration expenditure in Australia. It was suggested that the federal anti-uranium policies of the past had resulted in dwindling exploration investment, which had only recently started to recover. Submitters argued that a politically stable environment and bipartisan support for uranium mining would be necessary in order to boost the industry's activity in Australia.[23]

11.25 Missed opportunities for uranium exploration, as a result of mining restrictions, were raised by a number of witnesses. For example, the UIC noted that:

> … virtually no new uranium exploration has been undertaken in Australia since 1983, due in part to confused government policies on uranium mining and export.[24]

11.26 GA confirmed that, in addition to other factors, restrictions on uranium production also contributed to the dwindling exploration expenditure.[25]

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19 AMEC, *op. cit.*, p. 2.

20 GA, *op. cit.*, p. 18.

21 Compass Resources NL, *op. cit.*, p. 4.

22 *ibid.*, pp. 12, 13. See also: Cameco Corporation, *Submission no. 43*, pp. 3–4.

23 See for example: Cameco Corporation, *ibid.*, p. 3; Mr Cedric Horn (Southern Gold Ltd), *Transcript of Evidence*, 19 August 2005, p. 96; CSIRO, *Submission no. 37*, p. 8.

24 UIC, *op. cit.*, p. 10.

25 GA, *op. cit.*, p. 23.

11.27 More broadly, Eaglefield Holdings asserted that:

> … the ambivalent or negative policies of Governments in Australia to uranium projects generates a major disincentive for Australians to invest, at the predevelopment stage, in any resource project containing uranium.[26]

11.28 Compass Resources raised concerns about Australian exploration relative to its international competitors, observing that 'Australia lags behind Canada in exploration investment supporting the resource industry.'[27] It attributed this, in part, to the fact that equity markets in Canada have the benefit of predictable government policies on uranium exploration and mining. The Committee also notes the important role of the flow-through share scheme in Canada and points again to its recommendation in chapter three that such a scheme be introduced in Australia.

Polymetallic deposits

11.29 A further cost associated with uranium restrictions is that companies can effectively be obstructed from mining polymetallic deposits, which contain a number of different minerals. In the case of polymetallic deposits containing uranium, the extraction of other minerals necessarily precipitates uranium through a series of chemical processes. Eaglefield Holdings, owners of the Mulga Rock deposits (MRD) in WA, explained the conflicts involved in this predicament:

> We could not produce nickel from our resource without first removing the uranium … so we would have uranium in a solid form on the surface, in a drum, and the question is: what would we do with it? To suggest that we then tip it back in the hole is just ludicrous.[28]

Impact on states

11.30 Prohibition of uranium mining impacts directly on those states and territories that impose such restrictions. Not only do these states suffer from the missed opportunities identified above, they are particularly less attractive to some minerals companies because any uranium exploration in these areas would involve excessive risk. For example, Areva stated that:

> … there is significant potential for uranium discoveries in other states of Australia, but at the moment it prefers to explore in those

26 Eaglefield Holdings Pty Ltd, *op. cit.*, p. 4.

27 Compass Resources NL, *op. cit.*, p. 4.

28 Mr Michael Fewster, *op. cit.*, p. 29.

> states that are not opposed to the concept of uranium exploration or mining.[29]

11.31 Deep Yellow explained that exploration in the NT became more appealing following Federal Government clarification that new uranium mines could be developed in the Territory:

> That has changed our outlook a bit. Now we will proceed more confidently and undertake more work in the Northern Territory. Previously we had been looking outside the Territory for other opportunities.[30]

11.32 Southern Gold prefers to limit its operations to SA, whose government is more supportive of the uranium industry.[31] Likewise, Arafura Resources explained that, due to WA restrictions on uranium mining, the company would continue to concentrate its efforts in the NT:

> From a commercial perspective, there is too much risk for me, with a junior company with a small bank balance, to undertake exploration in WA without knowing that I may be able to take commercial advantage of that discovery. [32]

Costs to exploration and mining companies

11.33 Not only did state and federal economies miss out on opportunities as a result of uranium mining restrictions, exploration companies were also significantly disadvantaged or delayed. For example, Eaglefield Holdings argued that its projects in WA could be much further advanced:

> If it were not for the ban, we would effectively be two years into the project development phase and two years ahead of where we are now.[33]

11.34 Similarly, Cameco advised that its uranium exploration activities in WA were effectively on hold because of that state's uranium mining restrictions.[34]

Criticisms of restrictions on uranium exploration and mining

11.35 The Committee received extensive evidence outlining arguments against the present restrictions on uranium exploration and mining. For instance,

29 Mr Stephen Mann (Areva Group), *Transcript of Evidence*, 23 September 2005, p. 3.

30 Mr James Pratt (Deep Yellow Ltd), *Transcript of Evidence*, 23 September 2005, p. 82.

31 Mr Cedric Horn, *op. cit.*, p. 18.

32 Mr Alistair Stephens (Arafura Resources NL), *Transcript of Evidence*, 23 September 2005, p. 54.

33 Mr Michael Fewster, *op. cit.*, p. 29.

34 Cameco Corporation, *op. cit.*, p. 5.

Summit Resources insisted that policies hampering the development of new uranium mines in Australia:

> … cannot be justified on rational, factual, political, environmental, economic, commercial, scientific, hazard, health or safety grounds.[35]

11.36 AMEC also argued that uranium mining restrictions are futile, its view being that these policies:

> … serve no useful purpose. All these constraints do is to favour our global competitors, notably Canada, and deprive Australia of billions of dollars of export revenue and employment opportunities.[36]

11.37 The MCA argued that the existing restrictions on new mines are flawed for five reasons:

- the lack of production restrictions on existing operations is inconsistent with the intent of restricting new mines. MCA claimed that: 'It is quite absurd to be placing artificial limits on the number of mines but no such artificial limits on the size of current mines';
- the restrictions have 'no discernable effect on nuclear power generation elsewhere';
- Australia's safeguard arrangements are effective in restricting nuclear weapons proliferation, which is one of the reasons given for imposing restrictions on new uranium mines;
- the industry's environmental and social stewardship standards are very high and have improved to such an extent that they go beyond the regulatory requirements of the industry; and
- the risks associated with nuclear energy generation and waste management have reduced as a result of improving technology.[37]

11.38 Compass Resources noted the contradictory nature of the state policies in relation to uranium mining:

> Within Australia many in our industry are somewhat mystified as to why some states have selected uranium as a metal to black-list

35 Summit Resources Ltd, *op. cit.*, p. 2.

36 Mr Alan Layton (AMEC), *Transcript of Evidence*, 23 September 2005, p. 13.

37 Mr Mitchell Hooke (MCA), *Transcript of Evidence*, 5 September 2005, pp. 21–22.

> but at the same time are content that other states should continue with uranium mining and processing.[38]

11.39 Summit Resources argued that the exploration and mining prohibitions of the state governments are 'globally irrelevant' as other global suppliers, such as Canada, are prepared to make up any shortfall in Australian uranium supplies. Mining restrictions therefore do not have the desired effect of 'controlling the global supply and only reduces competition and serves to boost the uranium price.'[39]

11.40 Deep Yellow felt the mining restrictions were illogical on the grounds that they withhold uranium from countries that need nuclear energy to facilitate growth in an environmentally responsible manner:

> … there are countries … that need nuclear power as part of their energy mix if they are going to increase electricity supply and keep control of greenhouse gas emissions. I do not quite understand why Australia would deny assisting those countries by simply mining uranium, which is a safe, simple thing to do.[40]

11.41 Areva suggested that state governments reconsider their opposition to mining uranium:

> Ultimately it is a resource, it is a value to the population, it is a value to the Australian economy and it is a value to the world as far as reducing greenhouse gases, so it should be considered with an open mind rather than a closed mind.[41]

11.42 Although it was argued that restrictions adversely affect all industry participants, evidence suggested that prohibitions against uranium exploration and mining have a more severe impact on junior exploration companies and those companies not currently producing. Summit Resources contended that:

> Australia's current regulatory environment … favours the entrenched position of three existing producers and leaves limited opportunity for the development of other mines by new entrants … The two beneficiaries of this system are the three established Australian producers and the [rival] Canadian uranium industry.[42]

38 Dr Malcolm Humphreys (Compass Resources NL), *Transcript of Evidence*, 16 September 2005, p. 61. See also: Mr Alan Layton, *op. cit.*, p. 16; Mr Richard Pearce (Nova Energy Ltd), *Transcript of Evidence*, 23 September 2005, p. 79.

39 Summit Resources Ltd, *op. cit.*, p. 37.

40 Mr James Pratt, *op. cit.*, p. 83.

41 Mr Stephen Mann, *op. cit.*, p. 8.

42 Summit Resources Ltd, *op. cit.*, pp. 2, 4, 5, 35.

11.43 Jindalee Resources also argued that the current limitations on uranium exploration and mining were illogical, as these activities may be permitted in one state or territory, while at the same time being prohibited across the border in a neighbouring jurisdiction. It was claimed this system was 'anti-competitive' and perpetuated:

> … the entrenched position of [the] three existing producers and leaves limited opportunity for the development of other mines by new entrants.[43]

11.44 Among the companies that submitted to the inquiry, there was a consensus that it would be beneficial for the industry and to state and national economies if the states' mining and exploration restrictions were removed. The UIC stated that:

> It is important that state constraints on uranium mining and on proper consideration of nuclear power for Australia be removed.[44]

11.45 The MCA contended that, 'based on demonstrated safety and environmental performance of existing mines, the MCA sees no justification for restricting the establishment of further uranium mines in Australia.'[45]

11.46 Arafura, Jindalee and Nova agreed, supporting the lifting of mining restrictions in WA and other states. Cameco concurred and called for:

> … the support of both Federal parties and a change in position and attitude with respect to uranium in a number of States, in particular in Queensland and Western Australia … A change in political will and direction is required to give the clear message to companies that it is worthwhile exploring for uranium.[46]

11.47 Similarly, AMEC recommended that, 'there should be no undue restraint or discrimination against the development of uranium deposits' and, other than safeguards arrangements to ensure the peaceful use of Australian uranium, 'there should be no other constraints or restraints on the export of uranium.'[47]

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43 Jindalee Resources Ltd, *op. cit.*, p. 2.

44 UIC, *op. cit.*, p. 6.

45 MCA, , p. 9.

46 Cameco Corporation, *op. cit.*, pp. 3 and 6; Mr Alistair Stephens, *op. cit.*, p. 54; Arafura Resources NL, *op. cit.*, p. 10; Mr Donald Kennedy (Jindalee Resources Ltd), *Transcript of Evidence*, 23 September 2005, p. 59; Mr Richard Pearce, *op. cit.*, p. 71.

47 Mr Alan Layton, *op. cit.*, p. 13.

11.48 Arafura also encouraged the WA government to examine the data and facts associated with uranium mining rather than to be directed by a discussion based on 'emotion'.[48]

11.49 Although it was unclear how WA restrictions might be circumvented, Summit Resources recommended new 'Commonwealth powers to override the States and grant all necessary approvals for new uranium mines'.[49]

11.50 Eaglefield Holdings argued that WA State Government mining restrictions could not prohibit the mining of uranium on an existing mining lease (those without a 'no uranium mining' condition attached). If the State Government were to attempt this, 'they would have to resume ownership of the uranium, and that would obviously bring about issues of compensation and also sovereign risks.'[50] Eaglefield Holdings argued that 'theoretically, both Yeelirrie and Kintyre could be mined, or at least they could start a mine there, start mining uranium, process it … and put it in a drum.'[51] However, the State Government could prohibit the movement of the uranium oxide concentrate (UOC) off the lease by preventing movement of radioactive materials on public roads.

11.51 Eaglefield Holdings speculated that the provisions of the Commonwealth Constitution relating to trade between the states could perhaps be 'tested to see whether it would be allowable to move yellowcake, particularly, for example, if it was transported on a private road' from WA to SA.[52] The private road specifically cited was the access road on the trans-Australian railway line. However, Eaglefield observed that companies with mining leases had no appetite to bring court action against the Western Australian Government.

11.52 Nova Energy, owners of the Lake Way and Centipede uranium deposits in WA, noted that although the mining lease at its Centipede deposit was issued *prior* to the current WA Government policy prohibiting uranium mining, the industry can only progress with the support of the State Government:

> The company … does believe that the industry can only progress in a sustainable way through a supportive government policy and

48 Mr Alistair Stephens, *op. cit.*, p. 56.
49 Summit Resources Ltd, *op. cit.*, pp. 5, 35.
50 Mr Michael Fewster, *op. cit.*, p. 31.
51 *ibid.*
52 *ibid.*, p. 32.

> legislation at *all* levels which recognise uranium as an important commodity in the context of global energy needs world wide.[53]

Conclusions

11.53 The Committee agrees that restrictions on uranium mining and exploration have clearly impeded the growth of the uranium industry in Australia. Restrictions have resulted in numerous costs, including economic benefits foregone—not only for the companies concerned, but also to the states and the nation as a whole. Prohibitions on mining and exploration have impeded investment in the industry, resulted in a loss of employment and wealth creation opportunities, royalties and tax receipts. Australia has clearly failed to realise its potential as an exporter of uranium, despite possessing the largest share of the world's uranium resources.

11.54 Moreover, the Committee agrees that restrictions are inconsistent and illogical in so far as they restrict new mines from being developed, but do not prevent greater production from the three existing mines. That is, if the purpose of prohibitions is to restrict the amount of Australian uranium entering the fuel cycle worldwide then they manifestly fail. In this way, restrictions only benefit the three existing producers (and overseas producers, notably the Canadian mining industry), and are anticompetitive.

11.55 The Committee is convinced that existing restrictions on uranium mining and exploration should be lifted. The Committee's preference is for state and territory governments to work in a spirit of bipartisanship with the Federal Government in order to bring about a change to the present restrictions. The Committee hopes that in due course a bipartisan and nationally consistent position on the benefits and regulation of uranium mining might emerge.

53 Mr Richard Pearce, *op. cit.*, p. 70. Emphasis added.

Recommendation 8

The Committee recommends that the Australian Government Minister for Industry, Tourism and Resources, through the Council of Australian Governments and other means, encourage state governments to reconsider their opposition to uranium mining and abolish legislative restrictions on uranium (and thorium) mining and exploration, where these exist.

Regulatory inconsistency

> *Australia's regulatory system must be structured to ensure strict standards of health, safety and environmental protection, while at the same time allowing predictability and avoiding unnecessary duplication.*[54]

11.56 Whilst companies were generally supportive of the regulations that govern the industry, some submitters expressed frustration with inconsistencies and duplication of processes between jurisdictions, as well as the regime's alleged complexity. Flaws in the regulatory system were identified by a number of witnesses as being significant impediments to the uranium mining industry. For instance, Nova Energy argued that:

> … the lack of alignment between State and Federal policies is the greatest impediment to the industry's development. [The current regulatory framework] does not provide a positive framework to develop the uranium industry.[55]

11.57 Compass Resources observed that whilst state governments regulate the minerals industry competently, the inconsistency across states in relation to uranium was perplexing. It suggested that the complex regulatory framework 'presents a danger of duplication and unreasonable delays in the approval process for new projects'.[56]

11.58 The MCA also criticised the lack of regulatory uniformity, particularly between SA and WA. It identified 'the Commonwealth's retention of ownership of uranium in the NT following self-government' as a key difference between the two jurisdictions. It further stated that:

> There is no uniform regulatory approach to the current operation of uranium mining in Australia, with the industry subject to

54 Areva Group, *op. cit.*, p. 2.

55 Nova Energy Ltd, *op. cit.*, p. 25.

56 Compass Resources, *op. cit.*, p. 3. See also: Dr Malcolm Humphreys, *op. cit.*, p. 62; Mr Mark Chalmers (Heathgate Resources Pty Ltd), *Transcript of Evidence*, 19 August 2005, p. 96.

> Australian Government/State/Northern Territory laws and regulations regarding mining and exploration permits and rights, safety and health, environmental issues and Native Title land rights. It is also subject to export controls and Australia's safeguards policies, which are administered by the Australian Government.[57]

11.59 Summit Resources noted that the application process for a uranium development proposal is lengthy and involves a great deal of duplication. It explained that, following lengthy data collection processes and various studies, applications need to be made to local government authorities, a number of state and territory government authorities, as well as several Federal Government agencies. Summit added that:

> … the proposal is then subject to an extensive period of public scrutiny and comment from any interested parties, whether or not they are directly impacted by any part or phase of the proposal.[58]

11.60 Summit Resources suggested that the regulatory regime is unbalanced, noting that:

> … no other mine or energy development is subject to such stringent, complex, detailed and lengthy approval' processes whilst also being subjected to 'a large degree of political risk.[59]

11.61 The UIC argued that:

> The current regulatory regime is onerous for the industry, particularly in comparison with industries such as agriculture, forestry, tourism and manufacturing.[60]

11.62 Nevertheless, inefficiencies of the regulatory framework were claimed to result in unnecessary delays for no benefit; there were claims that the regulatory environment is 'anti-competitive', and even a suggestion that the overly stringent regulatory framework has not taken into account the shift in public opinion on uranium mining.[61]

Environmental regulation

11.63 Environmental regulation was thought to be an area that could potentially involve duplication between jurisdictions. The UIC argued that:

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57 MCA, *op. cit.*, pp. 2, 11.

58 Summit Resources Ltd, *op. cit.*, pp 35–36.

59 Summit Resources Ltd, *ibid.*, p. 36.

60 UIC, *op. cit.*, p. 16.

61 Mr Stephen Mann, *op. cit.*, p. 5; Jindalee Resources Ltd, *op. cit.*, p. 2.

> … legislative and regulatory requirements should ensure the highest possible standards of occupational and public safety and environmental protection, while avoiding duplication and unnecessary administrative burdens and costs.[62]

11.64 Moreover, Compass Resources warned that, in such a complex regulatory environment, federal legislation, such as the *Environment Protection and Biodiversity Conservation Act 1999*, could be 'misused to delay or even destroy projects, if guidelines are not clearly established'.[63]

11.65 Duplication in the area of environmental regulations was a concern to some submitters. The Committee sought an opinion on WA's recent decision to augment the environmental approval process, and Mr Stephen Mann, of Areva, responded that:

> … the approval processes that we seem to be getting in many parts of Australia seem to duplicate previous processes. I think there have always been adequate processes in place … and all that is happening is that it is being dragged out for longer periods of time.[64]

11.66 The UIC urged:

> … the Commonwealth, states and territories to continue to work together to ensure a transparent and efficient method of environmental assessment of major projects.[65]

Reporting requirements

11.67 Whilst acknowledging the importance of ensuring public access to information about incidents that pose environmental or safety risks, the industry felt that this needed to be balanced against protecting the industry's reputation from misleading or exaggerated public comment.

11.68 It was suggested that reporting requirements imposed on uranium mining companies may mitigate against public understanding by potentially providing material for those who wish to misrepresent the industry's operational impacts. For example, the UIC noted that:

> … some operations are required to publicly report spills that have no environmental or safety significance. Such reporting can lead to unnecessary public concern or misrepresentation of operational impacts … The right of the public to be informed about matters

62 UIC, *op. cit.*, p. 16.

63 Compass Resources NL, *op. cit.*, p. 3.

64 Mr Stephen Mann, *op. cit.*, p. 5.

65 UIC, *op. cit.*, p. 16.

> that can affect safety or the environment is acknowledged but this needs to be balanced with the right of the industry to have its reputation protected from exaggerated or misleading public comment …[66]

11.69 While expressing the company's willingness to adhere to all reporting requirements, ERA noted that the industry operates under a very low reporting threshold. Even very minor accidents, such as 'a spill of a litre of oil in the pit'[67], are reported.

11.70 Additionally, the industry expressed a view that the reporting requirements for the uranium industry were much more stringent than those of other industries handling hazardous materials, the UIC suggesting that:

> lf corresponding [reporting] requirements were placed on other industries handling hazardous materials there would be an outcry.[68]

Access to land

11.71 Native Title was seen to have a particularly adverse effect on operations in the NT, WA and Queensland.[69]

11.72 More broadly, the NTMC stated that regulations governing access to land were complex and varied according to the type of land being accessed—that is, Aboriginal freehold or 'land vested in the Northern Territory'.[70]

11.73 The Commonwealth Scientific and Industrial Research Organisation (CSIRO) referred to the difficulties associated with access to land, noting that:

> Many prospective Uranium deposits are located in culturally or environmentally sensitive regions of Australia, making access challenging.[71]

11.74 A number of mining companies argued that challenges associated with accessing land are major impediments to the uranium industry. In particular, the NTMC claimed that the *Aboriginal Land Rights (NT) Act 1976*

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66 UIC, *ibid.*, pp. 16–17. See also: Nova Energy Ltd, *op. cit.*, p. 26.
67 Mr Harry Kenyon-Slaney (ERA), *Transcript of Evidence*, 24 October 2005, p. 51.
68 UIC, *op. cit.*, pp. 16–17. See also: Nova Energy Ltd, *op. cit.*, p. 29.
69 Mr Donald Kennedy, *op. cit.*, p. 67; Mr Cedric Horn, *op. cit.*, p. 14.
70 NTMC, *Submission no. 51*, pp. 7–8.
71 CSIRO, *op. cit.*, p. 4.

(ALRA) and *Native Title Act 1994* are complex pieces of legislation that should be amended to allow better workability.[72]

11.75 The Committee notes the intention of the Australian Government to introduce changes to the ALRA so as to improve the workability of the legislation for the benefits of mining companies and traditional land owners.[73]

The need for changes to the regulatory framework

11.76 Most uranium exploration and mining companies saw a need to ensure the regulatory environment does not become worse, and, in some cases, called for the system to be actively minimised. A number of suggestions were made by witnesses.

11.77 Compass Resources understood the need for Federal Government oversight to ensure industry compliance with national and international obligations. It asserted, however, that any review processes should be 'kept simple, efficient and timely so as not to become a significant cost burden for Australian operators'.[74] Regulations relating to the uranium industry 'should not be overly complex and bureaucratic'.[75] Compass Resources claimed that ensuring a balanced approach to regulation will allow the Australian uranium industry to 'maintain a comparative advantage' over international rivals.

11.78 There was broad agreement that the regulatory environment needs to be changed. Compass Resources argued that:

> If Australia is to respond to the growing opportunities presented by the nuclear industry a positive regulatory approach and an efficient and effective review and approval structure will be needed.[76]

11.79 Heathgate Resources felt that the need to improve the regulatory framework would become more urgent as the industry continues to grow:

> As the industry continues to develop in the country, there will need to be an additional focus remaining on these regulations to ensure they are consistent and to avoid duplication across Australia.[77]

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72 NTMC, *op. cit.*, p. 4.

73 Northern Land Council, *Transcript of Evidence*, 24 October 2005, pp. 20-29.

74 Compass Resources NL, *op. cit.*, pp. 2–3.

75 *ibid.*

76 *ibid.*

77 Mr Mark Chalmers, *op. cit.*, p. 96.

11.80 Compass Resources also suggested that a 'priority agency' be established to manage the 'layers of review in different agencies'[78] at both state and federal levels.

11.81 Jindalee Resources called for the regulatory environment in Australia to be simplified and streamlined in order to 'encourage investment in exploration, associated technology and the development of new mines.'[79]

11.82 Heathgate Resources argued that a more streamlined and less confusing regulatory system 'would be helpful to both speed up approval process[es] and ensure inadvertent mistakes do not occur.'[80]

11.83 Paladin Resources called for the removal of regulatory duplication between state and federal jurisdictions.[81]

11.84 While most uranium mining companies were concerned that there should be a consistent regulatory regime across Australia, Cameco went further and advocated a regime that:

> … really is a federally chartered regulatory oversight so that the standards, wherever you are doing business and exploring and trying to develop a uranium mine, would be the same …making it a federally managed and regulated material, [taking] it out of the jurisdiction-by-jurisdiction issue.[82]

11.85 Mr Cedric Horn, Chairman of Southern Gold, accepted the need for the current regulatory framework in ensuring that uranium is only supplied to signatories of the Nuclear Non-Proliferation Treaty. He agreed that the current restrictions are appropriate and adequate, but stressed the importance of keeping uranium exports as competitive as possible. To this end, he warned against the introduction of any other restrictions that might have an adverse impact on trade.[83]

Suggestions for change

11.86 A number of potential solutions were offered by submitters, and several of them are outlined below. Broadly speaking, however, the industry advocated the simplification and streamlining of regulatory processes.

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78 Compass Resources NL, *op. cit.*, p. 3.

79 Jindalee Resources Ltd, *op. cit.*, p. 5.

80 Heathgate Resources Pty Ltd, *op. cit.*, p. 4.

81 Paladin Resources Ltd, *Submission no. 47*, p. 7.

82 Mr Jerry Grandey (Cameco Corporation), *Transcript of Evidence*, 11 August 2005, p. 13.

83 Mr Cedric Horn, *op. cit.*, pp. 17–18.

11.87 Southern Gold advocated an urgent review of the regulatory structure, to ensure a framework exists to promote exploration and uranium mining, particularly for the benefit of junior exploration companies.[84]

11.88 The MCA argued for a regulatory regime that involves:

- open and competitive markets;
- 'minimum effective regulation';
- incentives for exploration; and
- incentives that help address market failure.[85]

11.89 The Committee addresses the issue of support for exploration by flow-through share schemes and provision of regional precompetitive geoscience data in chapter three.

11.90 In order to encourage a consistent regulatory environment and minimal duplication between jurisdictions, the MCA recommended the following avenues be pursued:

- involvement of the Council of Australian Governments (COAG) in the ongoing review of legislation pertaining to uranium mining, with a view to minimising the regulatory impact of existing and proposed legislation;
- adoption of a 'minimum effective regulation' approach to structuring the regulatory environment;
- minimisation of regulatory costs to the industry; and
- consideration of self-regulation or de-regulation of the minerals sector in certain situations.[86]

Sovereign risk and political uncertainty

11.91 Sovereign risk, an issue closely related both to state uranium policies and the regulatory regime governing uranium exploration and mining, was a concern of several submitters. Sovereign risk may be defined as:

> The risk for mineral companies from governments making adverse changes to operating conditions from those pertaining when a decision is made to invest in exploration or mine development; commonly relates to adverse changes in legislation, terms of

84 Southern Gold Ltd, *op. cit.*, p. 10.

85 MCA, *op. cit.*, p. 12.

86 *ibid.*

> consent to mine, taxation, repatriation of profits or funds and is assessed from a country's track record for making such changes.[87]

11.92 In the context of the inquiry, 'sovereign risk' was used by uranium mining companies to indicate the risk a company faces of having commenced development activities on the understanding that it has permission to mine any uranium identified, and then having that permission withdrawn.

11.93 Compass Resources stated that if a state government issues a uranium exploration licence to a company, that company should, upon satisfying all relevant regulations, be entitled to commence mining. Compass argued that if the state government does not intend to allow mining rights to uranium, uranium should be expressly excluded from the exploration licence. It was suggested that this would prevent companies diverting scarce resources into searching for a commodity that could not be mined. To do otherwise would raise the issue of sovereign risk:

> We know Australia has a great reputation as a low sovereign risk country; however, if states issue exploration rights to companies without the intention of approving developments, that national reputation will be called into question.[88]

11.94 A further complication in the context of uranium mining is the requirement for support from both state and federal legislatures. While the Federal Government may support uranium mining, opposing policies by a state or territory government could prevent such activity in that particular state or territory. The converse is also true: state government support for uranium mining would require complementary federal government policies before such mining could take place.

11.95 This requirement for congruent policy positions at both state/territory and federal levels of government, combined with the long lead times involved in developing a uranium mine, increases the risks that mining companies must face. That is, mining development could commence in a supportive political climate, only to see a change in government at state or federal level, with development subsequently halted.

11.96 This scenario was encountered by Summit Resources in its efforts to develop the company's uranium resources at its Mt Isa deposits in Queensland. In 1996 the company was assured by the then state government that it would support Summit's exploration program and, if

87 P Hancock, *Sustainable Development and the Australian Minerals Sector,* Parliamentary Library, Research Paper 24, 2000-01, Parliament of Australia, viewed 21 June 2006, <http://www.aph.gov.au/LIBRARY/pubs/rp/2000-01/01RP24.htm>.

88 Dr Malcolm Humphreys, *op. cit.*, p. 62.

successful, grant Summit a mining license to mine uranium. With this support, from 1996 to 1998 Summit expended some $5 million on drilling, metallurgical test work and pre-feasibility studies. However, in mid 1998, the newly elected Beattie Government indicated that it would not approve new uranium mines and Summit suffered a $60 million plunge in its market capitalisation.[89]

11.97 This experience has led Summit Resources to conclude that the current system 'is inherently flawed and gives rise to serious issues of sovereign risk.'[90] Summit noted that there have been several other (non uranium) operations that have suffered serious commercial losses as a result of similar political risk and changes of policy. It was argued that the legislation currently in place in Queensland is not problematic; the difficulty lies in the differing policies between the current government and those of the government in office when the company's tenements were initially granted.

11.98 Sovereign risk, combined with the inherently expensive feasibility studies that are necessary prior to having a mining licence granted, were identified by Summit Resources as mitigating 'against proceeding without State and Federal guarantees that, should the studies prove positive and all guidelines be met, the mine will be granted [a mining licence]'.[91] However, Summit Resources acknowledged that it would be difficult for such guarantees to be given in a Westminster parliamentary system such as Australia's, wherein governments cannot legally bind succeeding governments. Nonetheless, Summit Resources:

> … would like to see that we are not facing this uncertainty of either a federal change in government or a state change in government during our feasibility studies … it would cost us in the order of $20-odd million to achieve those. That is a significant expenditure, with the doubt left there that we might get to the end of that and not be granted approval.[92]

11.99 Summit Resources stated that the regulatory environment in Australia must 'deliver certainty to the approval process where large investments are required over several years for new mines to be brought on stream.'[93]

11.100 The MCA endorsed the creation of a regulatory framework to assign and charge for mining rights, with minimal government intervention once this

89 Summit Resources Ltd, *op. cit.*, p. 31.

90 *ibid.*, p. 33.

91 *ibid.*, pp. 4–5, 34.

92 *ibid.*, p. 12.

93 *ibid.*, p. 5.

framework has been established. This course of action would result in greater certainty in relation to mining rights, and would mitigate against sovereign risk.[94]

11.101 The MCA emphasised the fundamental importance of mining rights to the mineral sector:

> Before exploration and any subsequent development of any mineral deposits can take place, the nature and certainty of the right to explore, develop and mine resources needs to be established and clear to all parties.[95]

Government assistance and support

11.102 Existing producers and junior exploration companies contended that no substantial government assistance is given to the uranium industry in Australia. Indeed, it was suggested that any support the industry did receive from the Federal Government was either recouped through various charges levied against producers, or was negated by more substantial assistance offered to competing industries. For example, the UIC noted:

> There are no subsidies, rebates or other financial mechanisms provided specifically for the uranium industry. In fact state and federal geological surveys and scientific organisations have directed virtually no resources to uranium over the last 20 years, constituting a negative subsidy when compared with other mineral commodities.[96]

11.103 The Minister for Foreign Affairs, the Honourable Alexander Downer MP, stated that the Australian Safeguards and Non-Proliferation Office (ASNO) provides services of benefit to Australian uranium exporters. He acknowledged, however, that:

> … the Government recoups about 40% of ASNO's annual costs for safeguards activities through the Uranium Producers Charge. This corresponds to full cost recovery for the proportion of ASNO's costs considered to be of direct benefit to the uranium industry.[97]

11.104 It was explained to the Committee that the Uranium Producers Charge (UPC) contains a component for future costs associated with Australian-Obligated Nuclear Material, and is levied on each kilogram of uranium

94 MCA, *op. cit.*, p. 2.
95 *ibid.*, p. 12.
96 UIC, *op. cit.*, p. 26.
97 The Hon Alexander Downer MP, *Submission no. 33*, p. 12.

produced. In October 2004, the UPC was set at 5.8192 cents per kilogram. This yielded $470 026 in 2004–05.[98]

11.105 Australia's taxation regime was seen by some explorers as being a hindrance to the uranium industry. Indeed, it was suggested that the taxation regime made it more difficult for locally operating companies to compete with minerals companies based in countries that provide financial incentives for economic development.[99]

11.106 Notwithstanding the Committee's appreciation of the need to provide government support to the renewable energy sector, the Committee noted frustrations expressed by the uranium industry at the paucity of government assistance and support.

11.107 The MCA referred to assistance given to competing, non-minerals industries, such as the Mandatory Renewable Energy Target arrangements, and argued that:

> Overall, the Australian minerals sector in fact receives negative assistance from government. In other words, it receives no net subsidies but in fact is penalised through assistance given to non-minerals industries.[100]

11.108 The UIC concurred, stating that:

> … if subsidies are available for wind in Australia, on the basis of carbon reduction, they should be equally available to nuclear.[101]

11.109 Southern Gold saw the Australian Government's role broadly as maintaining a stable economy and, specifically, competitive and predictably low interest and inflation rates and a consistently strong capital market.[102]

11.110 Southern Gold also, however, advocated more direct intervention by government. It stressed the need for the introduction of government incentives for new exploration, particularly as the world demand for uranium increases. It called for the Government to 'provide urgent incentives for uranium exploration by junior companies with the aim of ensuring the future prosperity of Australia.'[103]

11.111 The South Australian government's Plan for Accelerating Exploration (PACE) particularly attracted praise for accelerating the industry's

98 *ibid.*; ASNO Annual Report 2004-05, p. 78.
99 Southern Gold Ltd, *Submission no. 54.1*, p. 3; Mr Cedric Horn, *op. cit.*, p. 14.
100 MCA, *op. cit.*, p. 22.
101 Mr Ian Hore-Lacy (UIC), *Transcript of Evidence*, 19 August 2005, p. 96.
102 Southern Gold Ltd, *Submission no. 54.1*, p. 3.
103 Mr Cedric Horn, *op. cit.*, p. 14; Southern Gold Ltd, *op. cit.*, pp. 2, 6, 10.

growth. Under the PACE program, the state government subsidises drilling programs, dollar for dollar.[104]

Labour and skills shortages

11.112 The shortage of appropriately skilled labour for the uranium industry is an issue that was cited primarily by junior exploration companies in evidence to the Committee. It has been reported, however, that the shortage of skilled workers is a concern for the entire resources sector, with BHP Billiton noting that between 2005–2010 there will be a 30 000 shortfall in qualified tradespeople Australia-wide[105]

11.113 The Committee received evidence that the rapidly increasing demands of the resource industry have contributed to the shortage of skilled labour available specifically to the uranium industry. Southern Gold contended that:

> Boom times in the mining industry have led to a shortage of geoscientists, mining engineers, drilling contractors, miners and tradesmen.[106]

11.114 The Committee also heard that there was a shortage of contractors willing to work in the isolated regions in which uranium exploration and mining takes place, and that this also contributed to the general labour shortage.[107]

11.115 The labour and skills shortages have been attributed, in part, to a lack of educational institutions running courses in relevant disciplines. For instance, GA argued that 'there are no universities actually training in some of the key areas' of interest.[108]

11.116 Southern Gold suggested that, as a way forward, new federal subsidies, or other similar government funding, be provided to universities specifically training prospective members of the uranium industry workforce.[109]

11.117 Southern Gold nevertheless recognised the industry's responsibility to contribute to the provision of training for new workers, but suggested that this was a role that could be best fulfilled by the larger mining companies.

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104 Mr Cedric Horn, *ibid.*, pp. 14–15.

105 A Trounson, 'Bottlenecks a stopper for BHP', *The Australian*, 27 April 2006, p. 24; BHP Billiton Ltd, *Exhibit no. 56, Olympic Dam Pre-feasibility Study*, p. 41.

106 Southern Gold Ltd, *Submission no. 54.1*, p. 3. See also: Mr Cedric Horn, *op. cit.*, pp. 14–15.

107 Mr Cedric Horn, *ibid.*, p. 17.

108 Dr Ian Lambert (GA), *Transcript of Evidence*, 5 September 2005, p. 5.

109 Mr Cedric Horn, *op. cit.*, p. 14.

Impediments to existing producers

11.118 This section concerns the impediments identified exclusively by existing uranium producers who submitted evidence to the Committee.

11.119 Existing producers, as defined in this report (see paragraph 9.4), who provided evidence to the Committee, include:

- Areva;
- BHP Billiton;
- Cameco;
- ERA;
- Heathgate Resources; and
- Paladin Resources.

Government scrutiny of sales contracts

11.120 The Australian Government's uranium exports policy, first adopted in 1977 and described in chapter eight, introduced strict controls intended to safeguard Australia's uranium from diversion into military programs. Paladin Resources suggested that elements of this framework, such as strict oversight of marketing arrangements and sales contracts prior to their becoming effective, 'impeded the commercial development of Australia's resources (to the primary advantage of Canada).'[110]

Transportation

11.121 The Committee was informed that producers have had difficulty in shipping uranium. Uranium is classified as a 'Class 7' dangerous good, which has implications for its transportation, handling and storage. Heathgate Resources informed the Committee that, due to political sensitivities, UOC can be shipped only through ports in Adelaide and Darwin.[111]

11.122 Of particular concern to uranium producers is the availability of shipping companies willing to transport the mined uranium product:

> The nuclear industry and some other industries have been experiencing difficulties transporting uranium oxide concentrates

110 Paladin Resources Ltd, *op. cit.*, p. 2
111 Heathgate Resources Pty Ltd, *op. cit.*, p. 4.

> and other raw materials in bulk quantities that contain very low concentrations of naturally occurring radioactive material.[112]

11.123 It was noted that the availability of shipping companies willing to transport Class 7 goods has declined over recent years. This has impacted on the flexibility with which uranium miners can export their uranium, being forced to instead rely on more costly charter vessels.[113]

11.124 The UIC provided a summarised history of difficulties in shipping from Port Adelaide since 2000. This includes the cancellation of shipping services, introduction of new vessels unwilling to carry UOC, abundance of other commodities competing for shipping services, rail embargoes in North America, and increased charges. This led to a three-month trial in 2005, shipping UOC from Port Darwin via the Adelaide–Darwin railway.[114]

11.125 The reasons for denial of shipping services include the following:

- vessel owners and shipping companies have, since the events of 11 September 2001, become increasingly reluctant to transport Class 7 goods, as 'security and liability issues have become of increasing concern to shipping companies, port authorities and governments'[115];
- charter operators have refused to carry nuclear materials, citing high insurance costs and onerous requirements as the reason for this change; and
- many intermediate ports will not permit the transit of radioactive cargoes, which creates difficulties for ships operating between Australia and Europe or North America.[116]

11.126 Heathgate Resources stated that the denial of shipping services appeared to be increasing over time, adding a significant cost burden to producers. It attributed this trend to service providers and port authorities lacking adequate and accurate education about uranium products. It advocated the need to better inform the public (which is discussed further in the latter half of this chapter), suggesting:

> Greater acceptance of the uranium industry by local, State and Federal Governments, political parties, community groups and the public at large is likely to lead to improved acceptance of the

112 UIC, *op. cit.*, p. 13.

113 Mr Mark Chalmers, *op. cit.*, p. 101. See also: GA, *op. cit.*, pp. 2–3.

114 UIC, *op. cit.*, pp. 48–49.

115 GA, *op. cit.*, p. 13. See also: *ibid.*, p. 13.

116 GA, *op. cit.*, p. 13. See also: UIC, *ibid.*

industry and possibly reduce concerns about shipping denial and restrictions.[117]

11.127 Eaglefield Holdings noted that, even if mining restrictions in WA were to be lifted, 'it is unlikely that any of the deposits will be developed until a process is developed for the transport of uranium out of the State.'[118] It was explained that difficulties in shipping yellowcake from WA could be expected, and proposed that it would instead by shipped from Port Adelaide via Kalgoorlie.

Concerns of junior exploration companies

11.128 This section of the report concerns impediments identified exclusively by junior exploration companies that have submitted evidence to the Committee's inquiry.

11.129 Junior exploration companies, as defined in this report (see paragraph 9.5), who provided evidence to the Committee, include:

- Arafura Resources;
- Compass Resources;
- Deep Yellow;
- Eaglefield Holdings;
- Jindalee Resources;
- Nova Energy;
- Southern Gold; and
- Summit Resources.

Infrastructure

11.130 A number of junior exploration companies referred to difficulties encountered by the absence of infrastructure in areas where uranium deposits are located. Whilst major companies also encounter this challenge, the relative cost burden of establishing infrastructure is much higher for smaller non-producers.[119]

117 Heathgate Resources Pty Ltd, *op. cit.*, p. 4.
118 Mr Michael Fewster, *op. cit.*, p. 31.
119 See, for example: *ibid.*, p. 24; Mr Cedric Horn, *op. cit.*, pp. 19-20.

11.131 Southern Gold cited the lack of existing infrastructure as a significant impediment to the company's capacity to engage in uranium exploration. Mineral deposits generally occur in very remote parts of the country and are therefore difficult to access. This is particularly true given that there are often no existing roads, power, water and other essential services, accommodation or communication infrastructure.[120]

11.132 It was suggested that states and territories have a role to play in improving the accessibility of isolated regional areas in which mining companies wish to develop deposits, and also that government subsidies for the development of infrastructure in regional Australia would be helpful to the uranium industry. In particular, Southern Gold advocated the provision of subsidies to junior exploration companies for infrastructure development in regional Australia.[121]

11.133 When the Committee suggested any such subsidies may need to be funded through an increase in royalty payments to governments by uranium producers, Southern Gold argued that this would not be necessary. It maintained that the present royalty regimes were adequate to finance these infrastructure subsidies.[122]

Geoscientific data

11.134 Whilst junior mining companies were generally happy with the level of access state governments afforded to their geoscience data, there was a suggestion that there was scope to enhance the services provided by GA.

11.135 A number of junior mining companies commended state governments for their willingness to work with the industry, particularly in relation to allowing companies access to their geoscience data. Provision of this data obviated the need for companies to conduct some of their own surveys and increased the efficiency with which explorers could identify prospective areas.[123]

11.136 Jindalee Resources spoke highly of state and GA survey data:

> It is great stuff. The state governments will now give you all of their geophysical surveys on disk. You can get them for just about nothing. The Northern Territory government is sensational with

120 Southern Gold Ltd, *Submission no. 54.1*, p. 3.

121 *ibid.*, p. 5.

122 Mr Cedric Horn, *op. cit.*, pp. 19-20.

123 See, for example: Mr Donald Kennedy, *op. cit.*, p. 67.

> that. Instead of repeating the work that somebody else did five years ago you can get all of this on file now.[124]

11.137 There were, however, calls for the provision of additional free or very inexpensive, high quality geoscience data and new exploration technologies through GA. It was suggested that improvements in this area could remove some impediments to the industry's growth.[125]

11.138 The mining industry, through the MCA, noted the Australian Government's important role in providing 'pre-competitive geoscience information.' It expressed support for the Mineral Exploration Action Agenda proposal for GA to lead a 'new, national innovative geoscience program to underpin the discovery of the next generation of ore deposits.'[126]

11.139 The Committee addresses this issue and recommends along the lines proposed by submitters in chapter three.

Access to capital

11.140 An impediment unique to the junior uranium exploration companies seems to be the ability to access capital, a problem not encountered to as great an extent by major companies.

11.141 Eaglefield Holdings suggested that its difficulty in obtaining capital and in attracting investors is partly due to the lack of political stability surrounding the uranium issue in Australia, particularly in WA.[127] The company observed that the best investment offers it is receiving to raise large amounts of capital to develop its resource are coming from offshore. Eaglefield observed that there is a disparity between what Australian and foreign investors, particularly Canadian investors, are prepared to pay for uranium resources. It warned that this trend could result in more and more of Australia's uranium resourced becoming foreign-owned.[128]

Influence of other industries

11.142 A number of junior exploration companies alleged that other industries play a role in limiting the development of the uranium industry. Jindalee Resources claimed that the sway of the Australian power, coal mining and coal export industries, as well as the revenue these industries generate for

124 *ibid.*
125 Mr Cedric Horn, *op. cit.*, pp. 18, 21.
126 MCA, *op. cit.*, pp. 3, 23.
127 Mr Michael Fewster, *op. cit.*, p. 30.
128 *ibid.*

state and federal governments, has stifled the debate on alternative energy sources, including uranium.[129]

11.143 Summit Resources suggested that the dominance of the Australian power and coal industries limits the informed consideration of uranium as an alternative fuel source.[130]

11.144 Southern Gold advocated the imposition of a carbon tax on fossil fuels used for power generation. It was argued that the internalisation of the greenhouse costs of fossil fuels would make low emission nuclear energy relatively more affordable.[131]

Conclusions

11.145 The Committee notes the wide range of impediments to the industry's development identified by existing uranium producers and juniors. Among these impediments, companies identified regulatory inconsistencies across states and territories, unnecessary regulatory complexity, and the potential for duplication between levels of government. A lack of uniformity exists in relation to laws and regulations governing mining permits and rights, safety and health, environmental issues, Native Title and land access. These inconsistencies cause confusion, delays in approvals processes and generate unnecessary complexity.

11.146 It was noted that regulation governing uranium mining is onerous and exceeds that imposed on any other mining sector. It was stressed that excessive regulation can undermine the industry's international competitiveness. Companies called for regulatory requirements and approvals processes to be simplified and streamlined. It was suggested that a 'priority agency' be established in each jurisdiction that companies can seek approvals from.

11.147 The Committee notes calls by Cameco for federally chartered regulatory oversight of uranium mining. However, most companies believe that state governments regulate mining effectively and that they have long experience and competence in this area.

11.148 While the Committee believes that stringent regulation of the uranium industry is justified, regulation should be the minimum necessary in order to: ensure the safety and health of workers and the public; minimise environmental impacts; uphold the interests of Traditional Owners; and ensure consistency with Australia's international obligations.

129 Jindalee Resources Ltd, *op. cit.*, p. 3.

130 Summit Resources Ltd, *op. cit.*, p. 21.

131 *ibid.*, p. 11.

11.149 The Committee is concerned that companies wishing to develop uranium mines face major uncertainties. Given the long lead times required to develop deposits, there is at present a very real possibility that federal and state government policies towards uranium will not be aligned over the period of years required to take uranium deposits through the stages of development, leading to projects having to be abandoned. Projects may be abandoned despite substantial investments having already been made in delineating and developing a resource, or in undertaking feasibility studies. The Committee is sympathetic to the predicament of companies that have found themselves in this uncertain and frustrating position. This situation points again to the urgent need for a bipartisan and consistent policy approach towards uranium across tiers of government.

11.150 The Committee agrees that the industry receives no net subsidies from government and is effectively penalised through assistance given to non-minerals industries.

11.151 The Committee was concerned to hear of difficulties encountered by existing producers in shipping uranium. Companies attributed denial of shipping services to service providers and port authorities lacking adequate and accurate education about uranium products, an issue the Committee addresses in the second half of this chapter.

11.152 Junior uranium exploration companies, which the Committee acknowledges in chapter three are performing a vital role in the industry, commented on the absence of infrastructure in remote regions, the need for regional pre-competitive geoscience data, and financial incentives for exploration.

11.153 The Committee believes that the impediments identified in this report should be examined by governments in partnership with industry, so that the industry's growth might be encouraged. The Committee notes that a start has been made towards this objective through the Uranium Industry Framework project sponsored by the Australian Government.

Recommendation 9

The Committee recommends that the Australian Government, through the Council of Australian Governments, seek to remedy the impediments to the development of the uranium industry identified in this report and, specifically:

- **develop uniform and minimum effective regulation for uranium exploration and mining across all states and territories;**
- **ensure that processes associated with issues including land access, Native Title, assessment and approvals, and reporting are streamlined;**
- **where possible, minimise duplication of regulation across levels of government;**
- **address labour shortages, training and skills deficits relevant to the industry; and**
- **address transportation impediments, and particularly issues associated with denial of shipping services.**

Perceptions and misconceptions of the industry

11.154 The Committee received extensive evidence concerning public perceptions of the uranium industry and of nuclear power. Indeed, submissions to the inquiry and witnesses who appeared before the Committee identified this as such a significant barrier to the industry's growth that the issue is given extended treatment in the following section.

11.155 This section discusses the following aspects of the perceptions and misconceptions of the uranium industry:

- public perceptions of uranium mining and nuclear power;
- factors that have influenced public opinion;
- impacts of misinformation;
- recent shifts in perceptions; and
- strategies to correct misconceptions and better inform the public.

Public perceptions of uranium mining and nuclear power

11.156 Witnesses appearing before the Committee acknowledged that the uranium industry had traditionally struggled with its public image. ERA, for example, observed:

> Winning public support for uranium mining is a difficult challenge in Australia, even as other countries see nuclear power as part of a solution to global warming.[132]

11.157 The issue of uranium mining arouses moral outrage on the part of some members of the public, typified by individuals who expressed the following views to the Committee:

- 'I write to express my disgust at the continuing policy of allowing uranium to be mined in and exported from this country.'[133]
- 'To continue to mine uranium … shows callous disregard for justice and intergenerational equity, contempt for the human race'.[134]
- 'I am not only strongly opposed to the development of nuclear energy in Australia (or anywhere) but morally outraged that it is even being considered given the abundance of evidence we have that proves there is NO working solution to nuclear waste …Those who allow the development of a nuclear energy industry condemn our species to certain death.'[135]
- 'I am convinced beyond question that uranium mining and nuclear power are not only physically unsafe, dangerous and deadly, but that they have already killed. A decision to maintain or expand uranium mining and nuclear power will kill human beings.'[136]

11.158 However, it is unclear how widely held these views are among the general public. For instance, in a March 2005 Morgan Poll 60 per cent of respondents were in favour of mining Australia's uranium, while only 30 per cent opposed it. Indeed, the Morgan Poll has consistently found majority support for uranium mining in Australia since the question was

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132 ERA, *op. cit.*, p. 4. See also: Mr Jerry Grandey, *op. cit.*, p. 7.
133 Ms Rita Warleigh, *Submission no. 83*, p. 1.
134 *ibid.*, p. 2.
135 Ms Stephanie Riddel, *Submission no. 80*, pp. 1–2. Emphasis in original.
136 Mr Daniel Taylor, *Submission no. 85*, p. 1.

first asked in 1977.[137] Moreover, a majority of Australians (58 per cent) agree with Australia exporting uranium to China.[138]

11.159 Nova Energy identified a number of commonly-held misconceptions about the uranium industry, which it suggested were 'emotive rather than rational and may, deliberately or otherwise, engender community fear and distrust of uranium mining …'[139] Nova's list of 'typical assertions by anti-nuclear groups', accompanied in its submission by factual responses, includes:

- Uranium mining is 'dirty and unsafe';
- Nuclear energy is unsafe;
- Nuclear power is expensive compared to other power sources;
- There are considerable CO_2 emissions in the total nuclear cycle;
- Nuclear waste cannot be safely transported or stored and poses a long-term threat to the environment;
- Energy conservation reduces the need for nuclear power;
- Renewable energy is a viable alternative to nuclear energy; and
- More reactors will increase the risk of nuclear weapon proliferation.[140]

11.160 A number of witnesses expressed their frustration at the public's perceptions of the dangers of radiation from uranium. Jindalee Resources pointed out that all fossil fuels are radioactive to an extent, and that, 'in its concentrated form, with all the residue, coal is fiercely radioactive, yet we use it as a filler in cement.'[141]

11.161 Southern Gold made the point that:

> Radiation occurs naturally and inevitably in our environment and radiation levels can vary considerably. All living things have evolved in an environment where there are significant levels of background radiation.[142]

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137 Roy Morgan Research, *Finding No. 3845*, 22 March 2005, viewed 8 May 2006, <http://www.roymorgan.com/news/polls/2005/3845>. See also: Summit Resources Ltd, *Exhibit No. 77*, *Presentation by Mr Alan Eggers*, p. 16.

138 Roy Morgan Research, *Finding No. 4009*, 13 April 2006, viewed 22 May 2006, <http://www.roymorgan.com/news/polls/2006/4009/>.

139 Nova Energy Ltd, *op. cit.*, pp. 26–28.

140 *ibid.*

141 Mr Donald Kennedy, *op. cit.*, p. 58. See also: Mr Alistair Stephens, *op. cit.*, p. 51

142 Southern Gold Ltd, *op. cit.*, p. 5.

11.162 Evidence presented to the Committee suggests that issues associated with radioactive wastes are poorly understood by the general public. As discussed in chapter five, and noted by Arafura Resources, the disposal of radioactive waste is technically resolved, yet the public is still 'overshadowed by fearful misconceptions.'[143]

11.163 Heathgate Resources emphasised the need to compare the waste management for nuclear power with those of alternative fuel sources, arguing that:

> When you look at the small quantities that are generated from nuclear power plants relative to the quantities of waste that come out of these other sources, like coal … it stacks up very well.[144]

11.164 Cameco agreed there is a need to compare the volume of wastes produced by competing sources of energy. It argued that the waste resulting from 40 years of nuclear power generation is minimal. Whilst acknowledging that spent fuel is highly radioactive, Cameco stated that it decays rapidly and returns to its natural level of radioactivity within 200 years, during which time it is stored safely.[145]

11.165 Mr John Reynolds noted that concerns over the handling, storage and reprocessing of radioactive material had featured prominently in the uranium debate that took place in the late 1970s. He suggested there was a 'residual perception that this is the ultimate reason why nuclear power'[146] was not pursued in Australia, which may explain the current misconceptions regarding the safe handling of radioactive wastes.

11.166 Witnesses felt that public perceptions of supposedly inadequate uranium industry regulations were unfounded. To highlight this issue, one witness suggested it was easier to produce explosives than it was to access uranium.[147]

11.167 Eaglefield Holdings argued that the general public hold wildly inaccurate views about the risks associated with transporting UOC:

> Yellowcake is actually about the least hazardous of all commodities that you can put on the back of a truck. By way of analogy, countless truck loads of sodium cyanide are shipped to the goldfields each year. Each one of those truck loads of sodium cyanide would be 1,000 times more dangerous than a truck load of

143 Arafura Resources NL, *op. cit.*, p. 6.
144 Mr Mark Chalmers, *op. cit.*, p. 103.
145 Mr Jerry Grandey, *op. cit.*, p. 9.
146 Mr John Reynolds, *Submission no. 5*, p. 6.
147 Mr Alistair Stephens, *op. cit.*, p. 57.

> yellowcake … All it goes to show is that those who would oppose uranium mining in Western Australia have succeeded in the public relations war up until now. Yellowcake is almost entirely benign.[148]

Factors that have influenced public opinion

> *It is easier to sell fear than it is reason.*[149]

11.168 Factors that have influenced public opinion and generated negative perceptions towards the uranium and nuclear power industry were identified as including:

- the education system and mass media;
- misrepresentations by interest groups;
- previous nuclear-related incidents;
- historical opposition to uranium and nuclear power; and
- uranium industry reporting requirements.

The education system and mass media

11.169 It was suggested that some of the negative perceptions have resulted from the Australian education system, at primary, secondary and tertiary levels. This reflected limitations in the syllabus and lack of teacher education about uranium and nuclear power.

11.170 Professor Kemeny identified poor education as one of the most significant contributors to the perpetuation of anti-nuclear sentiments in Australia, noting that important issues concerning uranium mining and nuclear power 'are still largely being debated at radio talkback program levels.'[150]

11.171 The ANF argued that the teaching profession, school and tertiary curricula, and media in Australia have failed to present a balanced view of nuclear power and uranium mining:

> I have had quite some international experience and I would say that, of people from all the countries I know, Australians are the most antinuclear in their sentiment. It comes, first of all, from the schools and, second of all, from the news media. A recent survey showed that the most antinuclear people in our community are

148 Mr Michael Fewster, *op. cit.*, p. 32.

149 Mr Mitchell Hooke, *op. cit.*, p. 30.

150 L Kemeny, 'A power too good to refuse', *The Australian*, 30 March 2005, p. 34.

> television and news journalists, and this is where the public get their information.[151]

11.172 Areva cited anecdotal evidence of children being taught very anti-nuclear and anti-uranium views in school, as a result of their teachers' lack of education about particular aspects of nuclear power. These misconceptions were then transferred to parents through their children.[152]

11.173 Mr Keith Alder was also critical of the way nuclear power has been discussed and taught at school level:

> One of the worst things has been the teachers. One of the organisations that I could have mentioned among the 37 that were prolifically antinuclear … was the Teachers Federation. At Lucas Heights we had the experience of sending literature to high schools and it coming back, sometimes torn in half. I went to a couple of high schools and, on one occasion, I met the then President of the Teachers Federation. We went into the library and it was covered in antinuclear literature. They would not have what we sent them, which originated from Vienna from the International Atomic Energy Agency, because it was 'loaded'. The librarian would not have it and the teachers would not have it.[153]

Misrepresentations by interest groups

11.174 Mr Alder suggested that antinuclear feeling has been deliberately stimulated by 'green groups' determined to target Australia:

> I do believe that some of the big organisation such as Greenpeace deliberately stimulated antinuclear feeling in Australia … this was told to me by two prominent members of Greenpeace who changed their minds. They said that it was quite deliberate because if you want to stop something you cut off the fuel. Therefore, Australia was made a target … the Australian population became the most antinuclear population on earth because of the constant antinuclear propaganda which was put to them.[154]

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151 Dr Philip Moore (ANF), *Transcript of Evidence*, 16 September 2005, p. 44. See also: Mr Stephen Mann, *op. cit.*, p. 4.

152 Mr Stephen Mann, *ibid.*

153 Mr Keith Alder, *Transcript of Evidence*, 16 September 2005, p. 83.

154 *ibid.*, pp. 83–84.

11.175 Evidence also suggested that, historically, the opposition of anti-nuclear groups has not been 'motivated, or otherwise supported, by the evidence.'[155]

11.176 Professor Kemeny suggested that 'the false assessment of nuclear risk is a favoured strategy of Australia's radical anti-nuclear activists'.[156]

11.177 Cameco suggested that opponents of nuclear energy also perpetuate misinformation about nuclear waste, in order to maintain a final 'unresolved' challenge to wider use of nuclear power.[157]

11.178 Dr Patrick Moore, co-founder of Greenpeace and former opponent of nuclear energy, acknowledged the one-sided nature of nuclear debates of the past and stated that:

> … it certainly is about time that we had an intelligent conversation about this subject, and got away from the scare tactics, and talked science, and economics and environment.[158]

Previous nuclear-related incidents

11.179 Jindalee Resources noted that one of the major difficulties of addressing public misconceptions associated with nuclear power and uranium is the tendency people have of associating all things nuclear-related with atomic bombs and the devastation of Hiroshima.[159]

11.180 ERA suggested public perceptions of uranium mining in Australia were due to its perceived connection with 'British and French nuclear testing at Maralinga and in the South Pacific'.[160] This association has 'tended to reinforce negative attitudes to uranium mining and the nuclear fuel cycle.'[161]

11.181 Public perceptions have also been shaped by accidents, such as Chernobyl and Three Mile Island. In particular, Areva commented that public perceptions of reactor safety are still shaped by Chernobyl and fail to appreciate the technical developments that have occurred since that accident:

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155 M Nahan, 'The nuclear power debate', *IPA Review*, Institute of Public Affairs, June 2005, viewed 8 May 2006, <http://ipa.org.au/files/57-2-politicsofnuclearpower.pdf>.

156 L Kemeny, 'Pseudo-science and lost opportunities', *Quadrant*, July-August 2005, p. 55.

157 Mr Jerry Grandey, *op. cit.*, p. 10.

158 Dr Patrick Moore, 'Greenpeace co-founder welcomes nuclear debate', *AM*, ABC Radio, 8 June 2006, 08:16:00, transcript of interview with David Weber.

159 Mr Donald Kennedy, *op. cit.*, p. 61.

160 ERA, *op. cit.*, p. 4.

161 *ibid.*

> Most of the public see reactor designs as being similar to the Chernobyl design and having the same problems … the designs are dramatically different now. Even the Chernobyl design, as has been commonly stated, would never have been built in the Western world. The technology was far greater in the Western world than what it was in Chernobyl at the time that it was built. We have moved on. Last year we [Areva] spent €402 million on research and development. The company spends a lot of money continuously, year after year. Many other companies are also doing that and trying to improve the technology and to improve the safeguards. I do not think the general population understand or realise the safeguards that exist now following the September 11 incidents. People were talking about aeroplanes flying into nuclear reactors. Aeroplanes can fly into any of the modern nuclear reactors and it would automatically shut down. There would not be any contamination. I do not think people really understand that.[162]

11.182 Cameco acknowledged that these accidents reflected weaknesses in the industry's performance in the past. It argued, however, that the industry has 'been living with that and responding to it as an industry since [the incidents] occurred in 1979 and 1986.'[163]

Historical opposition to uranium and nuclear power

11.183 Mr Keith Alder argued that the antinuclear climate in Australia is a legacy of the large number of groups, principally unions, historically opposed to uranium mining and nuclear power, combined with the fact that so few organisations have been prepared to advocate in favour of nuclear power:

> At the time I retired—which was February 1982—we counted up the number of active bodies in Australia promoting antinuclear feeling. There were 37. There were two organisations promoting the positive side: the Australian Atomic Energy Commission and the Uranium Information Centre, which started then. Of the 37 … more than half were trade unions …
>
> Who is putting the positive side to the population today? The Atomic Energy Commission used to be promotional; ANSTO is not. The Uranium Information Centre, to my knowledge, is the only organisation that is presenting a positive line on uranium. From the public point of view, the public look at the federal opposition and see that it is antinuclear. They look at the federal

162 Mr Stephen Mann, *op. cit.*, p. 10. See also: Nova Energy Ltd, *op. cit.*, p. 15.
163 Mr Jerry Grandey, *op. cit.*, p. 11.

> government and what do they see? That nuclear energy is not on the agenda. Do you wonder that they are confused and that they are anti? Everything is pointing them in the wrong direction.[164]

11.184 It was submitted that the future expansion of the uranium and/or nuclear power industries in Australia would improve public perceptions of the industries. It was suggested that the negative attitudes towards nuclear power in Australia are, in part, due to the public's lack of contact with the industry in the past. Heathgate Resources noted that the general public's perceptions of the relative risks of nuclear power are starkly different to the views of people actually involved in the industry.[165]

11.185 Summit Resources also alleged that 'the entrenched position of the Australian power, coal mining and export industries' has also unduly swayed public policy and has 'stifled informed debate on … uranium in Australia'.[166]

Uranium industry reporting requirements

11.186 As discussed above, the UIC and Nova Energy suggested that the unique and stringent reporting requirements imposed on the uranium industry may impede the public's understanding of the industry's true impacts. For example, being required to publicly report spills that have no environmental impact could lead to the industry being subjected to 'exaggerated or misleading public comment about its operations.'[167]

Impacts of misinformation

11.187 Nova Energy contended that 'misunderstandings and at times misinformation about uranium and nuclear issues' has resulted in uranium mining and nuclear energy both becoming 'contentious issues in the public's eye.'[168]

11.188 Similarly, the ANF felt that this public cautiousness about, and opposition to, the nuclear industry has influenced state governments' policies:

> In Australia opposition to nuclear activities has been vociferous but clearly not too numerically strong … This has led to

164 Mr Keith Alder, *op. cit.*, p. 83.

165 Mr David Brunt (Heathgate Resources Pty Ltd), *Transcript of Evidence*, 19 August 2005, p. 104.

166 Summit Resources Ltd, *op. cit.*, p. 21. See also: Jindalee Resources Ltd, *op. cit.*, p. 3.

167 Nova Energy Ltd, *op. cit.*, p. 26. See also: UIC, *op. cit.*, p. 16.

168 Mr Richard Pearce, *op. cit.*, p. 69.

> governments adopting antinuclear positions and enacting legislation prohibiting certain nuclear related activities.[169]

11.189 Professor Kemeny agreed that false perceptions held by the public, and the subsequent fear these have produced, have restricted the uranium industry's development in Australia:

> For more than three decades the Australian community has been assailed with false perceptions of danger or high risk … In the absence of sound education and informed realism, some will react to this with fear and anger.[170]

11.190 Paladin Resources argued that 'Australia's attitudes and policies governing uranium … have been based on misconceptions, ignorance, and the occasional deliberate lie.'[171] It maintained that this has resulted in 'unjustifiable restrictions … and the perpetuation of negative attitudes towards nuclear power'.[172]

11.191 Similarly, Mr Mike Nahan, Executive Director of the Institute of Public Affairs (IPA), claimed that the factually erroneous campaigns conducted by anti-nuclear groups since the 1970s had resulted in uranium mining being the most closely regulated of all mining activity. Indeed, he noted that:

> … despite the absence of evidence and the weakness of their arguments, the anti-nuclear campaigners have been successful in limiting mining of uranium in Australia.[173]

11.192 Areva drew the Committee's attention to the detrimental effect of negative public perceptions on uranium exploration activities in Australia. It suggested that recent increases in uranium exploration activity were partly a response to increased world demand for uranium, but were also due in large part to 'local influences such as a more balanced assessment of the nuclear industry by some legislators, commentators and the public at large.'[174]

11.193 ERA argued that negative public perceptions resulting from adverse incidents, such as British and French nuclear testing at Maralinga and in the South Pacific, had 'led some State Governments to oppose mines, particularly in Western Australia and Queensland.'[175]

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169 Mr James Brough (ANF), *Transcript of Evidence*, 16 September 2005, p. 43.

170 L Kemeny, 'Pseudo-science and lost opportunities', *loc. cit.*

171 Paladin Resources Ltd, *op. cit.*, p. 2.

172 *ibid.*

173 M Nahan, *loc. cit.*

174 Areva Group, *op. cit.*, p. 13.

175 ERA, *op. cit.*, p. 4.

Recent shifts in perceptions

11.194 A number of industry representatives expressed the view that public sentiment had shifted dramatically, having become much more positive towards uranium mining and nuclear power over the last 12 months:

> I would say that, in the last year, you would have had to be asleep not to notice that perhaps once or twice a week in the national press there is a fairly positive article on uranium mining. It has been in other forms of media as well. I believe the debate has swung a long way in the last 18 months—further than I would have said if you had got me in here 18 months ago. Then, I would have said that it was a very difficult issue and the public are not going to be with us. I do not believe that any longer. I really think it has swung along way.[176]

11.195 This shift has been illustrated in opinion poll results:

> There was a Newspoll some weeks ago in the *West Australian* — and I have to say that the results were very surprising to all of us in the uranium industry — which found that 48 per cent of those surveyed supported uranium mining in Western Australia and only 44 per cent opposed it.[177]

11.196 Further, a Westpoll conducted in June 2006 indicated that, 'nearly 70 per cent of West Australians support an inquiry into the feasibility of a nuclear power industry in Australia …'[178]

11.197 Deep Yellow attributed the allegedly dramatic shift in community attitudes to the global warming issue. It was suggested that the public had become more supportive of nuclear power because it had come to accept that 'global greenhouse gases and global warming is more of a threat than uranium mining'.[179]

11.198 The shift was also the result of the public's increasing awareness of the shortcomings of renewable energy in effectively meeting energy demands:

> I think that awareness is growing … I think a lot more people understand that now than did 12 months ago, but I do not think the broader community really understands. A lot of people still

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176 Mr Alan Eggers, *op. cit.*, p. 16. See also: Dr Michael Goldsworthy (Silex Systems Ltd), *Transcript of Evidence*, 9 February 2006, p. 3.

177 Mr Alistair Stephens, *op. cit.*, p. 54.

178 G Mason, 'Poll shows WA support for inquiry into nuclear industry', *West Australian*, 12 June 2006, p. 6.

179 Mr James Pratt, *op. cit.*, p. 83.

> think that renewables might be able to do a lot more than they actually can.[180]

11.199 Areva contended that the increased awareness of uranium mining was also due to the recent influx of junior exploration companies into the industry:

> … it has only been recently that between 30 and 40 new companies have come on board or have taken uranium under their wings. With that momentum there will be a lot more reply and a lot more comment. Over the last six months we have seen a lot more comment on some of these things than we ever saw in the previous 10 years.[181]

11.200 As discussed in chapter four, a number of prominent environmentalists and founding figures of environmental groups now also support nuclear energy as essential for the reduction of greenhouse gas emissions. These individuals include:

- Dr Patrick Moore, co-founder of Greenpeace;
- Sir James Lovelock, a prominent environmentalist, scientist and climatologist; and
- Bishop Hugh Montefiore, a prominent environmentalist, theologian and former trustee of Friends of the Earth.[182]

11.201 ERA noted that the attitude of the Australian environmental movement had not yet followed the lead of the international environmental community.[183]

11.202 Internationally, surveys show increasing public support for nuclear power. Examples of international polls include:

- Germany, 1998: 77 per cent support for the continued use of nuclear energy plants;
- United States, March 2004: 80 per cent of respondents indicated nuclear energy will be important in meeting US electricity needs; 67 per cent of respondents personally favoured the use of nuclear energy; two-thirds of self-described environmentalists favour the use of nuclear energy;

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180 *ibid.*, pp. 83–84. See also: Mr Alistair Stephens, *op. cit.*, pp. 54–55; Cameco Corporation, *op. cit.*, p. 1; Dr Timothy Sugden (Nova Energy Ltd), *Transcript of Evidence*, 23 September 2005, p. 78.

181 Mr Stephen Mann, *op. cit.*, p. 9.

182 See for example: Summit Resources Ltd, *op. cit.*, p. 21; Jindalee Resources Ltd, *op. cit.*, p. 3; Cameco Corporation, *op. cit.*, pp. 7–8.

183 ERA, *op. cit.*, p. 4.

- Sweden, March 2005: 83 per cent support for maintaining or increasing use of nuclear power;[184] and
- United Kingdom, November 2005: Majority of respondents (59 per cent) believe that nuclear energy will be a major contributor to energy supplies in the future. Further, 41 per cent of respondents supported new nuclear power plants being built to replace those being decommissioned, compared with 28 per cent opposed and 26 per cent with no opinion on the matter.[185]

Strategies to correct misconceptions and better inform the public

What needs to be done

11.203 The Committee notes that the first major Commonwealth inquiry into uranium, the *Ranger Uranium Environmental Inquiry*, which was presided over by Mr Justice R W Fox and reported in 1976 and 1977, concluded that it was vital that 'the public be kept fully informed of relevant facts.'[186] Moreover, the Fox report noted that 'there is a tendency on the part of some to misrepresent those facts' and concluded that accurate information pertaining to the uranium industry and nuclear power should be provided to the Federal Parliament and the general public.[187]

11.204 Throughout the course of the Committee's inquiry, the uranium industry consistently suggested that more needed to be done by way of educating the public about all aspects of the uranium and nuclear power industries, including information on radiation. For example, ERA discussed the necessity for 'more informed dialogue, less characterized by emotion.'[188] Arafura Resources suggested that there is a need to:

> … educate the population with a balanced view on how our resources can be used to prevent an environmental crisis.[189]

11.205 Paladin Resources felt that a change in public perception could be brought about if 'Australians understood the energy value of uranium oxide … in

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184 Information provided to the Committee by Mr Ian Hore-Lacy, UIC.

185 Market and Opinion Research International (MORI) Topline Findings, *Attitudes to nuclear energy*, MORI, 1 December 2005, viewed 8 May 2006, <http://www.mori.com/polls/2005/pdf/nia.pdf>.

186 R W Fox, *Ranger Uranium Environmental Inquiry First Report*, AGPS, Canberra, 1976, p. 184.

187 *ibid*.

188 ERA, *Exhibit No. 76*, p. 2.

189 Arafura Resources NL, *op. cit.*, p. 11; See also: Paladin Resources Ltd, *op. cit.*, p. 4; Mr Robert Parsons, *Submission No. 24*, p. 1.

comparison with coal or natural gas.'[190] Similarly, Nova Energy suggested that the public need to be made aware of the benefits of nuclear power compared with renewable energy, particularly in relation to its ability to provide baseload power.[191]

11.206 In addition to emphasising the environmental benefits of nuclear energy, the MCA submitted that shifting public perceptions requires communication of the adequacy of Australia's non-proliferation safeguard policies. Equally, it stressed the importance of communicating information about technological advances that have resulted in better management of safety risks and waste products associated with nuclear power generation.[192]

11.207 Mr Jerry Grandey, Chief Executive Officer of Cameco Corporation, stated that the best way to better inform the public about the nuclear industry was to be forthright and transparent:

> [Nuclear] has its share of technical problems — admit it. Say that the industry, like all industries is … improving itself. And then talk about the recognised cost benefits, security of supply benefits and environmental benefits in the context of an open debate, with full transparency.[193]

11.208 Chairman of Jindalee Resources, Mr Donald Kennedy, stressed the importance of educating teachers. He noted that, during the initial debate to permit the establishment of Olympic Dam in SA, the SA Chamber of Mines conducted a program of tours for primary school teachers to the mine and other uranium deposits in the Flinders Ranges. This program achieved the desired effect of contributing to a shift in public perceptions, highlighting the importance of educating the educators.[194]

11.209 AMEC also referred to the success of *Australian Student Mineral Venture* (ASMV). ASMV is a school program that funds visits of school groups to various mines throughout Australia.[195] Summit Resources also argued that public perceptions could be improved by a greater effort at 'education from preschool to university.'[196]

11.210 Areva suggested that university curricula for mining and engineering also be reviewed, citing a lack of coverage uranium has received in the past:

190 Paladin Resources Ltd, *loc. cit.*

191 Dr Timothy Sugden, *op. cit.*, p. 70. See also: Mr Stephen Mann, *op. cit.*, p. 3.

192 Mr Mitchell Hooke, *op. cit.*, p. 29.

193 Mr Jerry Grandey, *op. cit.*, p. 17.

194 Mr Donald Kennedy, *op. cit.*, p. 59.

195 Dr David Blight (AMEC), *Transcript of Evidence*, 23 September 2005, pp. 19–20.

196 Mr Alan Eggers, *op. cit.*, p. 13.

> The only university education that I had with regard to uranium or the nuclear industry was, quite literally, exposure to what pitchblende or uraninite looks like in year 1 mineralogy class. That was it. Everything I have learned about the nuclear energy industry and uranium exploration in general has been learned on the job since I became a geologist.[197]

Industry's role

11.211 There was an acceptance that the industry has a large role to play in correcting public misconceptions about the uranium industry through public education campaigns, by being vocal on the issue of uranium mining and nuclear energy, and by performing well.

11.212 The UIC was credited with helping to bring about shifts in public opinion over recent years, particularly through its provision of 'objective data and commentary'.[198] Silex Systems also stated that the UIC 'provides a marvellous educational forum in Australia with very high-quality factual educational material on the nuclear industry.'[199]

11.213 Eaglefield Holdings advocated that the uranium industry, particularly in WA, take part in well-funded and well-organised public information campaigns in order to better educate, and ultimately win the support of, the general public.[200]

11.214 Nova suggested that, in some situations, taking part in public education campaigns delivered value to shareholders, and could therefore be justified from a commercial standpoint:

> My view is that, as far as shareholder value goes, we have a uranium deposit that can be profitably developed and it will generate large amounts of vale for shareholders and the people of the country and the state, so it is appropriate for us to work towards developing that deposit, and if that means public education then I think it is an appropriate use of shareholders' funds, to a degree.[201]

11.215 It was suggested to the Committee that the uranium industry also had a responsibility to inform elected officials, in order to better inform debates in state and federal parliaments. Having observed recent parliamentary debates in WA, Nova Energy argued that there was a need to remedy:

197 Mr Damien Ewington (Areva Group), *Transcript of Evidence*, 23 September 2005, p. 11.
198 ERA, *op. cit.*, p. 4.
199 Dr Michael Goldsworthy, *op. cit.*, p. 18.
200 Mr Michael Fewster, *op. cit.*, p. 31.
201 Dr Timothy Sugden, *op. cit.*, p. 77.

> … the lack of knowledge or understanding of a large number of local politicians on both sides of the house. I think part of the process of improving community awareness is working to inform our state representatives far more effectively so they can actually carry out that debate and discussion with their communities.[202]

11.216 The Committee received evidence that the industry could soon be expanding its public education activities, as it considered:

> … the enhancement of a program of public education and information to augment work already being undertaken in this respect.[203]

11.217 Industry conceded that its past education efforts and engagement in public debate have been inadequate:

> I think the industry has been very tardy in its education and its support of the nuclear industry in Australia. Up until the last nine months, we have very rarely seen any responses to any negative press regarding nuclear power.[204]

11.218 Mr Grandey emphasised the importance of the industry continuing to perform well. Cameco's experience suggested that 'the best way of addressing public opinion is to stay out of the headlines, to put your head down and run a very clean operation' and to educate opinion leaders.[205] Cameco claimed the increased support for the industry in North America in recent years is:

> … not a function of public relations campaigns; it is a function of the US industry operating their plants extremely well and extremely safely, and staying out of the headlines.[206]

11.219 The SIA concurred, noting the important role that the regulatory system provides and the necessity that industry members comply with regulations:

> It is the responsibility of the industry to ensure that the general public's concerns are recognised … The emotion that is conjured up by the word 'nuclear' is real. People fear nuclear because they cannot see and touch it. Therefore, it is incumbent on the industry … to recognise that people are concerned. The best way to do that is to have the regulatory environment in which you work visible

202 Mr Richard Pearce, *op. cit.*, p. 79.
203 UIC, *op. cit.*, p. 17. See also: Nova Energy Ltd, *op. cit.*, p. 26.
204 Mr Stephen Mann, *op. cit.*, p. 8.
205 Mr Jerry Grandey, *op. cit.*, p. 7.
206 *ibid.*

> and capable of making pronouncements to the general public where appropriate … to put their minds at rest. It is the responsibility of any responsible operator of any kind of industrial plant.[207]

Government's role

11.220 Arafura Resources and Nova Energy asserted that government has an important role to play in ensuring that the public has a sound, non-emotive appreciation of the role of uranium mining. It was suggested that one way government could fulfil this role is by funding public education campaigns.[208]

11.221 Evidence received by the Committee suggested that the government has an important educational role to play by engaging in an open public debate on the issue, covering the 'recognised cost benefits, security of supply benefits and environmental benefits.'[209] The government could also be involved by funding some objective public education campaigns.

11.222 The ANF stated that information on the nuclear industry must come from a respected source: 'It needs to come from some authoritative people that the public has respect for and will accept what they say.'[210] While the ANF acknowledged the difficulty in identifying an agency to lead in this area of public information, potentially suitable agencies suggested included the Australian Academy of Science, CSIRO and, for radiation safety issues, the NHMRC.[211]

11.223 The ANF emphasised the need for the public to receive information specifically on radiation risks and the normal presence of background radiation. It was argued that government had a key role to fulfil in this regard:

> … if decisions are made to move forward with our uranium industry, we submit that governments must prepare the population by giving them clear and simple information on maters of uranium and radiation safety. For too long — for a generation at least — the nuclear industry has suffered from myth and misinformation in the media and the schools, leading to fear in the

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207 Mr John Thornton (SIA), *Transcript of Evidence*, 10 October 2005, pp. 36–37. See also: Deep Yellow Ltd, *op. cit.*, p. 2.

208 Mr Alistair Stephens, *op. cit.*, p. 57; Mr Richard Pearce, *op. cit.*, pp. 71–72.

209 Mr Jerry Grandey, *op. cit.*, pp. 2, 17; Mr Alan Layton, *op. cit.*, p. 15. See also: Mr Alistair Stephens, *ibid.*, p. 54.

210 Dr Philip Moore (AMEC), *Transcript of Evidence*, 16 September 2005, p. 46.

211 *ibid.*

> public mind. There always will be some controversy, but governments have a duty to inform and to lead.[212]

11.224 The MCA conceded that the state minerals industry bodies do have resources for advocacy, but was sceptical of the benefits of public education programs and instead emphasised the importance of governments in bringing about changes in attitudes:

> It kind of sounds arrogant to say we are going to go out and educate the public … Until state politicians start to talk about all the benefits and positives of nuclear power generation, it is unlikely that they are going to turn it around … If the politicians are saying, 'We used to have this policy and we now see no justification for it,' that is worth a hell of a lot more than all the publicity that we could generate …[213]

11.225 Cameco asserted that, unlike traditional fossil fuels that tended to be viewed as politically stable, public opinion on uranium mining has been politicised. Bipartisan support for uranium mining is therefore necessary before any shift in public opinion can be affected. Cameco commented that the shift in public perception in North America over the past several years has resulted from bipartisan support for the industry.[214]

11.226 Another role for government could be ensuring that a balanced view of nuclear energy is presented to children throughout their primary and secondary education:

> This is the place where the government could be intimately involved with educating people, not necessarily brainwashing them — I am not suggesting that by any stretch of the imagination — but at least providing some objective and balanced information about the pros and cons of the nuclear energy industry. [215]

11.227 There was also a suggestion that government activities, such as conducting inquiries into the industry, could assist in dispelling some of the myths surrounding the uranium industry in Australia:

> … inquiries like this certainly help to bring the attention of the industry and the issues to the people … Even from that point of view, I think the government has an involvement.[216]

212 Mr James Brough, *op. cit.*, p. 43.

213 Mr Mitchell Hooke, *op. cit.*, pp. 35–37.

214 Mr Jerry Grandey, *op. cit.*, pp. 2, 17.

215 Mr Damien Ewington, *loc. cit.*

216 Mr Stephen Mann, *op. cit.*, p. 4.

11.228 Finally, it was suggested that the expansion of the uranium industry would, in and of itself, produce more favourable public perceptions. Nova argued that the Australian public's lack of exposure to the uranium industry in the past had made it overly cautious of uranium mining. It ventured that, in the absence of adverse incidents, the more contact the public had with the uranium industry, the more supportive the populace would become.[217]

Conclusions

11.229 The Committee does not question the sincerity with which those people expressing 'moral outrage' at the very existence of the uranium industry hold their views. However, the Committee believes that these views are not informed by an accurate assessment of the benefits and risks associated with the industry. Misinformation and ignorance of the facts, as presented in evidence to the Committee, included: the failure to appreciate the true greenhouse benefits of nuclear power across the fuel cycle; nuclear power's safety record, which is far superior to all other major energy sources; massive overstatement of the known number of fatalities associated with the Chernobyl accident; the success of non-proliferation regimes; and the sophisticated management of waste, which is very small in volume compared with fossil fuel alternatives. There is also a general refusal to acknowledge the immense energy density of uranium and its value in a world where demand for energy may triple by 2050. There is no acknowledgement that uranium is Australia's second largest energy export in thermal terms, or nuclear's part in addressing the global energy imbalance. Such views, although held by perhaps a minority of people, do influence policy and this impedes the development of the industry.

11.230 Previous chapters of this report (five, six, seven and eight) address the three key arguments advanced in opposition to the expansion of uranium exports and of nuclear power—safety, waste and proliferation—and the misconceptions associated with these issues. Examples cited in this chapter included the risks associated with transporting uranium, and the risks associated with radiation exposure.

11.231 The Committee is convinced that while widespread misconceptions about the industry persist, the industry's growth will be impeded. As Eaglefield Holdings submitted in relation to misconceptions about the negligible health risks associated with transporting uranium from mines in Australia: 'those who would oppose uranium mining … have succeeded in the public relations war.'[218] However, the Committee is pleased to note

217 Dr Timothy Sugden, *op. cit.*, p. 73.

218 Mr Michael Fewster, *op. cit.*, p. 32.

that in light of the global warming threat there may be a shift occurring in public acceptance of the legitimacy of uranium mining and the use of nuclear power.

11.232 Factors that have contributed to negative perceptions of the industry have included the Australian public's lack of exposure to uranium mining and nuclear power in the past, which has led to a degree of ignorance about the industry and in turn created a climate in which myths and unfounded fears could be propagated. Ignorance and/or bias by sections of the teaching profession, and neglect of uranium and nuclear power from school and tertiary curricula may also have contributed. The opposition to uranium mining by environmental groups and some unions were also cited as factors in generating public antipathy to uranium mining and nuclear power.

11.233 The Committee believes that if a lack of balance in relation to uranium and nuclear power persists anywhere in Australia's school and tertiary curricula, it should be rectified.

11.234 The Committee notes that industry has, through state chambers of mines and energy, previously funded programs to educate teachers by conducting visits to uranium mines. The Committee believes that state chambers of mines and other industry bodies should be encouraged to conduct more schools and teacher programs of this kind. In addition, state chambers should also seek to educate representatives of the media and state political leaders.

11.235 One factor cited as adversely influencing public opinion was the onerous and arguably excessive reporting requirements to which the uranium industry is subject. No other industry is subject to such stringent reporting requirements. These requirements aid transparency, but may also provide material for those who wish to misrepresent the significance of incidents at mines. This is a particular concern given that such misrepresentations are received by a public that is not well informed about the nature of the industry's true impacts.

11.236 The Committee notes that even in 1976 the Fox inquiry concluded that 'the public be kept fully informed of relevant facts' and that 'there is a tendency on the part of some to misrepresent those facts.'[219]

11.237 The Committee concedes that finding the right balance between transparency versus the right of the industry to have its reputation protected from undue criticism is a difficult balance to strike. The

219 Mr R W Fox, *Ranger Uranium Environmental Inquiry*, First Report, Commonwealth of Australia, Canberra, 1976, p. 184.

Committee is pleased to note the preparedness of the industry to comply with reporting standards as they currently stand.

11.238 The Committee believes that progress could be made if, in addition to maintaining the currently rigorous reporting requirements, regulators issued a brief assessment of the impacts of any incidents that occur. A simple classification system could be devised that states simply whether the incident has 'no impact', 'minimal impact' and so on. In this way, companies will continue to report incidents and satisfy the public's desire to be informed about the industry, while regulators' assessments will better communicate the seriousness of the impacts of any incidents that may occur. In this way, the Committee hopes that public understanding of the real impacts of uranium mining operations will be enhanced and companies will be somewhat protected from unfounded criticism.

Recommendation 10

The Committee recommends that the Australian Government, through the Council of Australian Governments, examine incident reporting requirements imposed on uranium mining companies with a view to aiding public understanding of the real impacts of incidents that may occur at uranium mines. Specifically, the Committee recommends that companies continue to meet existing reporting thresholds, but that regulators be required to issue a brief assessment of each incident informing the public of the gravity of the incident and its likely impacts on the environment and human health. To this end, a simple and accurate incident impact classification system could be devised.

11.239 The uranium industry consistently emphasised the need for improved public eduction about all aspects associated with uranium mining and nuclear power. The Committee concurs with this view. It is imperative that the benefits and risks associated with uranium mining and use of nuclear power be more widely understood among the Australian public. Any concerns and unfounded fears should be addressed. Moreover, opinion leaders in Australia, particularly members of parliaments and the media, need to be better informed and provided with a more balanced perspective on the industry and its merits.

11.240 To this end, accurate and objective information about the industry needs to be made available by a credible and authoritative source or sources. In particular, evidence pointed to the need for information on radiation and radioactive waste management.

11.241 The Committee is well aware that across Australian Government agencies a considerable amount of relevant information is already being made available. For example, the Australian Radiation Protection and Nuclear Safety Agency provides information about radiation and health, the Department of Education, Science and Training provides information on radiation and radioactive waste management, and the Australian Safeguards and Non-Proliferation Office provides information on safeguards arrangements.

11.242 Industry has also contributed to increasing public understanding of uranium mining and nuclear electricity generation by funding the Uranium Information Centre, which provides comprehensive information on all aspects of the nuclear fuel cycle, uranium mining and the role of nuclear energy. Among its other activities, the UIC publishes continually updated nuclear issues briefing papers. The Committee applauds industry for establishing the UIC and making these outstanding information resources available to the public. The Committee is also aware of the 'Uranium SA' web site, prepared by the SA Chamber of Mines and Energy Education Program on behalf of companies in the uranium industry in SA.

11.243 Another relevant initiative is 'nuclearinfo.net', established by a group of scientists at the School of Physics at the University of Melbourne. The aim of the site is to provide authoritative information about nuclear power from a group that claims to have no vested interest in the industry.

11.244 Notwithstanding these efforts, the Committee believes that more needs to be done to ease the public's concerns, to better inform the public and dispel the persistent myths associated with uranium mining and nuclear power. Industry conceded that it had a greater role to play and observed that it should be prepared to engage in public debate where necessary.

11.245 Some industry bodies questioned the value of industry-funded public advocacy campaigns, arguing that without political leaders publicly talking about the benefits of nuclear power generation, industry campaigns were unlikely to be successful.

11.246 The Committee concludes that public education and advocacy needs to be augmented and the Committee believes that both industry and Government must play a part. In relation to the provision of information about uranium mining and nuclear power, it may be difficult to identify an authoritative agency or organisation that could serve this function. It is imperative that the organisation tasked with providing objective information command public confidence. It would need to have—and be seen to have—no vested interest in the industry. Suggestions of organisations that could potentially perform this role include the Australian Academy of Science, CSIRO, ANSTO, and the National Health and Medical Research Council. Information should preferably be available from a single source.

11.247 The Committee believes that as the industry expands in Australia, particularly in light of the agreement to export uranium to China, governments have a responsibility to inform the public about relevant issues that may cause concern. A communication strategy is therefore also justified to address concerns the public may have and address areas of poor understanding. This information should also be provided to political leaders at all levels and the media.

Recommendation 11

The Committee recommends that the Australian Government:

- **identify and fund an authoritative scientific organisation to prepare and publish objective information relating to uranium mining, the nuclear fuel cycle and nuclear power, including radiation hazards and radioactive waste management;**
- **support the scientific organisation identified above to develop a communication strategy to provide information to the public, media and political leaders to address concerns these groups may have in relation to uranium mining, uranium exports and nuclear power;**
- **seek to rectify any inaccuracies or lack of balance in school and university curricula pertaining to uranium mining and nuclear power;**
- **encourage industry bodies, including state chambers of mines, to conduct or augment programs to educate teachers, media and political leaders about the uranium industry;**
- **encourage companies to conduct programs of visits to uranium mines for teachers, school groups, media representatives and political leaders; and**
- **encourage industry to be forthright in engaging in public debate, where this may assist in providing a more balanced perspective on the industry and its impacts.**

12

Value adding — fuel cycle services industries, nuclear power, skills and training in Australia

For Australia – soon to displace Canada as the premier uranium exporter – to ignore the study of the uranium fuel cycle and its value-added technologies and industries indicates a pattern of intellectual and economic neglect possibly unparalleled in higher education policy and academic history.[1]

… Australia should seize the opportunity to maximise the financial return by not only selling more uranium but also adding value to the product by getting involved in other steps in the manufacture of nuclear fuel. Above all, we should sell uranium enriched to reactor fuel quality rather than simply selling uranium as yellowcake.[2]

In its own interests and as a contribution to the containment of greenhouse gas emissions globally, there is a strategic, economic and ethical case for Australia now, to include nuclear electricity generation in its energy infrastructure.[3]

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1 Professor Leslie Kemeny, *Exhibit no. 8*, *A power too good to refuse*, p. 1.

2 Mr James Brough (Australian Nuclear Forum), *Transcript of Evidence*, 16 September 2005, pp. 42–43.

3 Mr John O Reynolds, *Submission no. 5*, p. 4.

Key messages —

- **Currently, Australia simply mines and mills uranium ore, which is the lowest level of uranium beneficiation.**
- **Federal and state government decisions over the past 35 years have led to the abandonment of several opportunities to develop industries based on upgrading Australia's uranium resources for export. Perhaps the most significant of these missed opportunities involved a proposal to develop a commercial uranium enrichment industry in Australia by a consortium of Australian companies, the Uranium Enrichment Group of Australia—BHP, CSR, Peko-Wallsend and WMC—in the early 1980s. This proposal was terminated following a change of Federal Government.**
- **By the mid 1980s, the Australian Atomic Energy Commission (AAEC) had accrued twenty years of experience with uranium enrichment technology. The Commission had by then invested some $100 million on enrichment research alone. This knowledge and expertise was lost following the Federal Government's direction that the AAEC and its successor agency, the Australian Nuclear Science and Technology Organisation (ANSTO), abandon enrichment and other fuel cycle research.**
- **Australia possesses some 40 per cent of the world's uranium, perhaps more. By virtue of this immense resource endowment, Australia has a very strong economic interest in, and justification for, seeking to add value to its uranium resources prior to export. Such a development would allow Australia the opportunity to extract greater returns from its resource endowment, to develop sophisticated technologies and to expand its national skills base.**
- **The Committee supports the establishment in Australia of fuel cycle services industries which could, in accordance with International Atomic Energy Agency expert advisory group recommendations outlined in chapter seven, be established on a multinational or co-management basis, thereby increasing transparency and meeting non-proliferation objectives.**
- **By virtue of its highly suitable geology and political stability, Australia could also play an important role at the back-end of the fuel cycle, in waste storage and disposal. Again, such a development could be highly profitable, as well as possibly providing global security benefits. However, as noted in chapter five, the US Global Nuclear**

Energy Partnership initiative proposes to revolutionise spent fuel management (through the use of advanced burner reactors in the 'fuel supplier' nations), thereby generating waste that only requires short isolation periods. This could obviate the need for geologic repositories altogether.

- **The Committee has no in-principle objection to the use of nuclear power in Australia and believes that, subject to appropriate regulatory oversight, utilities that choose to construct nuclear power plants in Australia should be permitted to do so. There would be clear greenhouse gas emission and other technological and potential economic benefits from doing so.**
- **Nuclear power may not be immediately competitive in the Australian context, due to the quantity and quality of Australia's coal resources (and that carbon emissions are currently not priced). However, the Committee believes that if Federal and state governments continue to provide a range of incentives to achieve low carbon emissions, for example by subsidising renewables such as wind, then governments should not discriminate against nuclear power—which will achieve very low emissions but also generate baseload power, unlike the currently subsidised renewable alternatives.**
- **Even if deployment of nuclear power plants and other fuel cycle facilities in Australia is not imminent, steps should now be taken to develop a licensing and regulatory framework to support the possible eventual establishment of such facilities in Australia.**
- **The Committee is concerned that, with the closure in 1988 of Australia's sole university school of nuclear engineering, Australia no longer has an indigenous source of trained personnel in the nuclear field. The Committee concludes that the Australian Government should seek to progressively rebuild Australia's nuclear skills base. Among other initiatives, the Government should broaden ANSTO's research and development mandate, so that it is once again able to undertake physical laboratory studies of aspects of the nuclear fuel cycle that may be of future benefit to Australia and Australian industry. Consideration should also be given to re-establishing at least one university school of nuclear engineering.**

Introduction

12.1 The Committee's terms of reference and additional issues did not seek submissions relating to the possible domestic use of nuclear power or the question of establishing domestic fuel cycle services industries. However, a number of submitters volunteered opinions and information in relation to these matters. The Committee concludes its report with an overview of this evidence. The Committee also addresses itself to the skills base and research and development (R&D) activity to support Australia's current and possible future participation in the nuclear fuel cycle.

12.2 The chapter addresses the following issues in turn:

- Australia's history of 'missed opportunities' to add value to its uranium resources and to develop a domestic nuclear power industry;
- proposals to develop domestic fuel cycle services industries and specifically:
  - ⇒ uranium enrichment,
  - ⇒ nuclear waste treatment and disposal, and
  - ⇒ nuclear fuel leasing;
- the domestic use of nuclear power; and
- nuclear skills, training and R&D activity.

12.3 As the Committee's terms of reference concerned Australia's uranium resources, the evidence received in relation to these other matters is not exhaustive. The Committee also notes that these matters are being examined by the Prime Minister's Taskforce, appointed in June 2006, to review uranium mining, processing and nuclear energy in Australia. The terms of reference for the review include, inter alia, examination of the:

- potential for establishing other steps in the fuel cycle in Australia, such as enrichment, fuel fabrication and reprocessing;
- circumstances in which nuclear power could in the long term be economically competitive in Australia; and
- current state of nuclear energy research and development in Australia and the capacity for Australia to make a significantly greater contribution to international nuclear science.[4]

4 Prime Minister of Australia, *Review of Uranium Mining, Processing and Nuclear Energy in Australia*, 6 June 2006, viewed 6 June 2006, <http://www.pm.gov.au/docs/Review%20of%20Uranium%20and%20Nuclear%20Energy%20in%20Australia.pdf>.

Australia's 'lost opportunities' to value add

12.4 The Committee was informed of the Australian Government's previously extensive involvement in nuclear R&D activity, principally through the former Australian Atomic Energy Commission (AAEC), which was established in 1953. For over 30 years, until its re-establishment as the Australian Nuclear Science and Technology Organisation (ANSTO) in 1987, the AAEC was engaged in R&D across the nuclear fuel cycle, including uranium enrichment, nuclear reactor designs, and radioactive waste disposal:

- The Commission's initial research program involved studies into two reactor designs—high temperature gas cooled reactors, operating on a thorium/uranium cycle, and liquid metal cooled reactors. This research continued until 1966.
- In 1966 research was refocused towards the design and operation of heavy water reactors and into a number of other fields, including spent fuel reprocessing and nuclear desalination.
- In 1965 the AAEC commenced uranium enrichment research, which grew to become the largest single research program within the Commission. In the 1970s and 1980s two methods of enrichment were investigated—gas centrifuge and laser enrichment, with the main focus being centrifuge enrichment.
- In 1969 a project was commenced to construct a 500 megawatt electrical nuclear power station at Jervis Bay in NSW, based on the then widely held view that nuclear power was likely to be introduced into Australia in the 1970s. Federal budgetary constraints caused the project to be deferred in 1971 and abandoned in 1972. [5]

12.5 In addition to its own enrichment R&D program, from the beginning of the 1970s the AAEC was heavily engaged in international enrichment studies, including the following:

- The 'Washington Talks' (November 1971), in which the US expressed interest in a multi-national plant in Australia using gaseous diffusion technology;
- France-Australia study (1971–72) on the use of French gaseous diffusion technology for a plant in Australia;

5 The history of the AAEC and the research conducted by the Commission is described in Dr Clarence Hardy's *Atomic Rise and Fall: The Australian Atomic Energy Commission 1953–1987*, Glen Haven, Sydney, 1999.

- Association for Centrifuge Enrichment (ACE) Study (1973–74) with the European Tripartite countries (UK, Germany and the Netherlands); and
- Japan-Australia Study on Enrichment (1976–1978), for the possible establishment of a centrifuge enrichment plant in Australia for supply to Japan.[6]

12.6 In addition to these studies, the South Australian (SA) Government also conducted a Uranium Enrichment Study (1973–76), which also included the consideration of a possible conversion plant to manufacture uranium hexafluoride (UF_6), which is the interim stage between milling uranium and enrichment. In February 1976 the SA Uranium Enrichment Committee (UEC) recommended the establishment of a uranium processing centre at Redcliff, 30 km south of Port Augusta on the shores of the northern Spencer Gulf, incorporating a conversion plant and an enrichment plant (using centrifuge technology). The overall capacity of the plant was to convert 10 000 tonnes of uranium to UF_6 and then to 5 000 tonnes separative work units (SWU) of enriched uranium per year. The plant was to be established by the Commonwealth Government but with full State Government support.[7]

12.7 The UEC estimated that if uranium were enriched prior to export it would double the value of the initial mine product.[8] It was recommended that sales of uranium from Australian mines be made conditional on the refining and enrichment of such sales in the processing centre. The project was estimated to have provided permanent employment for 1 550 workers and further site development was proposed to include nuclear power generation and desalination of seawater. The UEC stated that:

> The project as a whole would be the largest development of its kind undertaken in Australia in recent years, comparable to the Snowy Mountains Scheme in money terms and impact on the Australian economy. The capital cost (including interest during construction) over an eight-and-a-half year period, is estimated at A$1400 million, and its potential earnings are set at nearly $426.5 million per annum.[9]

The project was finally abandoned by the SA Government in 1979.

12.8 In addition to the AAEC's own enrichment studies, in 1980 a private consortium, comprised of four companies (BHP, CSR, Peko-Wallsend and WMC) established the Uranium Enrichment Group of Australia (EUGA)

6 *ibid*., p.165.

7 SA Premier's Department, *Second Interim Report of the Uranium Enrichment Committee*, SA Government, Adelaide, February 1976, pp. 9.

8 *ibid*., p. 28.

9 *ibid*., p. 40.

as a joint-venture to carry out a pre-feasibility study to assess the commercial viability of establishing an enrichment industry in Australia. Following an interim and a final pre-feasibility report, which concluded, inter alia, that the establishment of a commercial enrichment industry would be feasible and likely to be profitable, EUGA proceeded to a feasibility study which was completed in 1982. It was proposed that gas centrifuge technology should be adopted, which would be obtained from the Tripartite CENTEC-URENCO companies, subject to necessary inter-governmental agreements on technology transfer.[10]

12.9 However, in 1983 the incoming Federal Labor Government indicated that it would not conduct the necessary technology transfer agreements with the Tripartite governments and the project was subsequently abandoned. The Labor Government also directed the AAEC to terminate its own enrichment program and to scale-down other nuclear fuel cycle work, with the exception of research into the 'Synroc' waste form for the management of high level radioactive waste.

12.10 Mr Keith Alder, who was appointed a Member of the Commission in 1968 and became the AAEC's General Manager from 1975 to 1982, presented his memoir, *Australia's Uranium Opportunities*, as evidence to the Committee. Mr Alder was overall director of the AAEC's research activities for 20 years and led the Commission's Jervis Bay Nuclear Power Station project.

12.11 Mr Alder argues that Australia had two real opportunities to embark on an enrichment industry—following the joint study with France in 1971–72 and the UEGA initiative, which was terminated in 1983. In both cases, the enrichment industry proposals were abandoned following changes in Federal Government. In relation to the termination of the EUGA proposal and, subsequently, the AAEC's enrichment research activities, Mr Alder argues:

> So, once again, a change in government in Australia stopped dead the prospects of establishing a worthwhile industry based on upgrading our natural resources for export.
>
> The companies involved in EUGA certainly believed in the commercial prospects of the industry. There can be no doubt Australia was in an excellent position to enter into very favourable arrangement for the technology transfer and future collaboration, and for growth of Australian industrial participation at a rate commensurate with market conditions …

10 Dr Clarence Hardy, *op. cit.*, p. 174

> Commercial and marketing studies and predictions carried out by EUGA and by the AAEC in support had shown potential annual export earnings from the enterprise to be in the range of $400–$800 million dollars by the turn of the century … A useful contribution to Australia's balance of payments problems, but we preferred to forgo it in favour of our misinformed political dogma …
>
> But worse was to come, for the same Government stopped all work in the AAEC on uranium fuel cycle topics, and closed down the AAEC research on enrichment, which had been in progress for nearly two decades, since 1965, at a cost approaching 100 million dollars.[11]

12.12 In his testimony before the Committee, Mr Alder reiterated that with the termination of the EUGA proposal: 'We lost an enormous opportunity then, which was a tragedy for Australia.'[12] The decision not to develop processing industries in the 1970s and 1980s was said to be 'disastrous in terms of lost opportunities for export earnings, jobs, and regional strategic influence.'[13] Mr Alder observed that, due to the decision to terminate the AAEC's enrichment research:

> As a result there is now … no work at all in Australia directed towards developing our uranium processing industry; this in a country holding well over 30 per cent of the world's economically recoverable uranium ores. We have thrown away successive opportunities …[14]

12.13 The Committee was also reminded that in the 1960s and 1970s virtually all the states were considering use of nuclear power, in addition to the Commonwealth Government:

> One of the main incentives for Jervis Bay … was to develop that whole framework for Australia before state generating bodies really were looking to go nuclear. When we did Jervis Bay in the 1960s everybody knew, including the electricity authorities of the states, that Australia was going to go nuclear in the 1970s. It was common knowledge. ETSA, the Electricity Trust of South Australia, had their own study group. They had done all their own estimates for a 250 megawatt plant on Kangaroo Island. The Victorian SEC had their own study group. New South Wales, of course, were our partners when we did the Jervis Bay [study]. Queensland had their own study group. ETSA from South

11 Mr Keith Alder, *Exhibit no. 2, Australia's Uranium Opportunities*, pp. 76–77, 78–79.

12 Mr Keith Alder, *Transcript of Evidence*, 16 September 2005, pp. 81–82.

13 Mr Keith Alder, *Submission no. 7*, p. 2.

14 Mr Keith Alder, *Exhibit no. 2, op. cit.*, p. 9.

> Australia had three engineers seconded to Harwell looking at nuclear power for South Australia when I was there in 1954.[15]

12.14 In May 1984, the Australian Science and Technology Council (ASTEC) completed a review of *Australia's Role in the Nuclear Fuel Cycle* ('the Slatyer Report', named after the ASTEC Chairman, Professor Ralph Slatyer). In conducting its review, Prime Minister Hawke directed ASTEC to examine, inter alia: Australia's safeguards arrangements; the opportunities for Australia, through its involvement in the fuel cycle, to further advance nuclear non-proliferation; and the adequacy of existing technology for the handling and disposal of waste products by consuming countries.[16]

12.15 Among its other findings, the Slatyer report concluded that Australia should participate in other stages of the nuclear fuel cycle, where such participation promotes and strengthens the non-proliferation regime. The Report suggested that the most suitable basis for developing an enrichment plant would be through the joint ownership and supervision of the appropriate facilities by Australia and other countries which share Australia's commitment to non-proliferation.[17]

12.16 However, the Hawke Government subsequently decided that it was not appropriate for Australia to become further involved in the nuclear fuel cycle—a policy which has been maintained by subsequent governments.[18]

12.17 In addition to state government legislative restrictions, Commonwealth legislation currently prohibits the establishment of uranium enrichment and other value adding industries and facilities in Australia:

- Section 140A of the *Environment Protection and Biodiversity Conservation Act 1999* prohibits the Minister for the Environment and Heritage from approving:

> … an action consisting of or involving the construction or operation of any of the following nuclear installations: a nuclear fuel fabrication plant; a nuclear power plant; an enrichment plant; or a reprocessing facility.[19]

15 Mr Keith Alder, *Transcript of Evidence*, *op. cit.*, p. 90. See also: UIC, *Nuclear Energy Prospects in Australia*, Nuclear Issues Briefing Paper No. 44, viewed 24 August 2006, <http://www.uic.com.au/nip44.htm>. Victoria's State Electricity Commission undertook preliminary studies on building a large nuclear plant on French Island in Westernport in the late 1960s.

16 ASTEC, *Australia's Role in the Nuclear Fuel Cycle*, AGPS, Canberra, 1984, p. 1.

17 *ibid*., p. 131.

18 See: UIC, *Uranium Enrichment*, Nuclear Issues Briefing paper No. 33, viewed 18 May 2006, <http://www.uic.com.au/nip33.htm>.

19 Mr Gerard Early (DEH), *Transcript of Evidence*, 10 October 2005, p. 11.

- Section 10 of the *Australian Radiation Protection and Nuclear Safety Act 1998* (ARPANS Act) prohibits the Australian Radiation Protection and Nuclear Safety Agency issuing a licence for the construction or operation of nuclear installations (fuel fabrication, enrichment, reprocessing or nuclear power plants) by any Commonwealth entity or on Commonwealth land.[20]

Value adding in Australia

12.18 The Association of Mining and Exploration Companies (AMEC) and others argued that 'as a general proposition, Australia has a history of producing the resources but we do not take it any further—we send our resources overseas.'[21] It was recommended that 'consideration and encouragement be given to developing and introducing various value-adding activities in Australia, particularly uranium enrichment'.[22]

12.19 Mr Robert Elliott submitted that:

> The emotion surrounding the nuclear fuel industry makes it tempting to remain with the current mine and export approach. I do not think that this serves the best interests of Australia or the world.[23]

12.20 Similarly, APChem Scientific Consultants questioned why it is that Australia, with such a significant share of world uranium resources, has failed to develop uranium processing industries:

> As the situation currently stands, Australia will continue to lag further behind in technological advances related to nuclear power and medicine … Continued expansion of uranium mining, without corresponding development of the nuclear industry within Australia will send this country down the well-worn path of selling its resources and assets and buying back the end products at exorbitant prices and a net loss to our economy.[24]

12.21 The ANF argued that Australia should value add across the fuel cycle and, in particular, enrich uranium for reactor fuel:

> Australia should seize the opportunity to maximise the financial return by not only selling more uranium but also adding value to

20 See: ARPANS Act, viewed 13 October 2006, <http://www.arpansa.gov.au/legframe.htm>.

21 Mr Alan Layton (AMEC), *Transcript of Evidence*, 23 September 2005, p. 20.

22 *ibid.*, p. 13.

23 Mr Robert Elliott, *Submission no. 1*, p. 1.

24 APChem Scientific Consultants, *Submission no. 38*, p. 4.

> the product by getting involved in other steps in the manufacture of nuclear fuel. Above all, we should sell enriched uranium to reactor fuel quality rather than simply selling uranium as yellowcake … We believe that Australia would be an ideal location for a fuel enrichment plant operating under multinational safeguards control such as recently suggested by the IAEA Director-General.[25]

12.22 Despite the 'lost opportunities' to establish industries to add value to Australia's uranium resources, Mr Alder remarked that Australia could still establish an enrichment industry:

> The opportunity to do that is still there, and the attraction of Australia as a place in which to do it is still there. In fact it is higher now than ever before because the demand for uranium is going up and Australian resources have increased. Australia is a very attractive place to overseas partners who want to go into the industry, just as they were attracted by our resources in 1982-83, when [the UEGA] enrichment study was done. It was not Australian science or Australian engineering that attracted the Americans, the French and the European Tripartite. They came to Australia in droves trying to sell us the idea that their technology would be used in Australia. The background for that has not changed, so we still have the opportunity.[26]

12.23 Furthermore, in his submission to the inquiry, Mr Alder argued that:

> There is still scope and opportunity for Australia to become a major fuel supplier to the nuclear power plants now operating and being built in many countries, and particularly in our Eastern neighbours e.g. Japan, China, Korea, Taiwan, India, Pakistan, and soon in Indonesia. We would need imported technology—we have lost what we had in the 1970's—but this has much to commend it, as it is likely that multinational plants for uranium enrichment and fuel manufacture will be favoured internationally because of their perceived advantages in preventing diversion of technology or fissile materials to weapons programs.
>
> There should be no difficulty in finding overseas partners for such enterprises—access to our uranium resources would provide the

25 Mr James Brough (ANF), *Transcript of Evidence*, 16 September 2005, p. 43.

26 Mr Keith Alder, *Transcript of Evidence*, *op. cit.*, p. 82.

> incentive, as it did for the international studies on uranium enrichment that we carried out in the 1970-80's.[27]

12.24 However, the Committee was cautioned that development of fuel cycle industries would require 'major shifts in Government thinking and policy making' from that of the past few decades.[28] Moreover, because Australian industry has had its 'fingers burnt badly … when it spent time and money on feasibility studies', Mr Alder argued that companies would need 'positive reassurance that the political climate would not change dramatically as it did in the past.'[29]

12.25 The ANF also argued that despite the missed opportunities to develop uranium enhancement industries:

> … it is better late than never, and it is the view of the ANF that the processes described for the production of finished reactor fuel elements should be re-examined to determine if such commercial enterprises can be established in this country. This will probably mean that partnerships with overseas companies or countries that have the commercially proven technologies will be required.[30]

12.26 In supporting the establishment of 'uranium enhancement industries' (conversion, enrichment and fuel fabrication) in Australia, the ANF noted that while uranium oxide exports in 2004 were valued at $410 million, if these other industries at the front-end of the fuel cycle were established in Australia the exported fuel could be worth in the order of $1.7 billion per year:

> This added value would not only mean greater income to this country but would be an important source of additional employment. Also, the production of reactor fuel here would facilitate the introduction of nuclear power if this were proven to be advantageous.
>
> Lastly, the operation of an enrichment plant will produce depleted uranium of an amount some seven times greater than the enriched uranium produced. This depleted uranium would constitute a tremendous energy asset for future use here and/or overseas [for use in breeder reactors].[31]

27 Mr Keith Alder, *Submission no. 7*, p. 2. See also: Mr Keith Alder, *Transcript of Evidence*, 16 September 2005, p. 81.

28 *ibid*.

29 *ibid*.

30 ANF, *op. cit.*, p. 3.

31 ANF, *Exhibit no. 4, Australian Uranium Enhancement Industries*, p. 1.

12.27 It was noted, however, that because any enrichment technology developed by the AAEC has probably now been lost and the two technologies (gas centrifuge and laser enrichment) being studied by the AAEC were never developed to the stage of commercial application, Australia would have to employ imported technology. Similarly, with fuel fabrication, because fuel elements must be able to coexist in reactors with fuel elements manufactured by other vendors, this means that designs may have to be licensed from foreign vendors until Australia developed sufficient experience.[32]

12.28 Mr Alder argued that: 'Australia should get into the front-end of the nuclear fuel cycle as soon as possible. That is, instead of exporting yellowcake, we should get into conversion to UF_6 and enrichment.'[33]

12.29 Professor Leslie Kemeny also argued that enhancing uranium prior to export would be financially beneficial for Australia and that there would also be global non-proliferation advantages from Australia's involvement in the back-end of the fuel cycle:

> Exporting yellowcake without value adding is just plain dumb. And being involved in reprocessing and waste disposal strengthens Australia's ability to guarantee global non-proliferation.[34]

12.30 The Institute of Public Affairs (IPA) also noted that the added value through the stages of the nuclear fuel cycle shows that mining uranium represents only a modest part of total fuel costs and that the largest components are enrichment and reprocessing. The cost components for 1 kg of nuclear fuel (uranium dioxide, UO_2) are listed in table 12.1. The data shows that enrichment accounts for some 21 per cent of total fuel costs and reprocessing/back-end activities contributes some 47 per cent of total costs.

32 *ibid*., p. 2.

33 Mr Keith Alder, *Transcript of Evidence*, *op. cit*., p. 89.

34 Professor Leslie Kemeny, 'Brace yourselves for a nuclear millennium', *The Australian*, 31 March 2006, p. 14.

Table 12.1 Costs to produce and reprocess 1 kg of UO_2 reactor fuel in US$, 2004

Process	Amount required	Cost (per kg or SWU)	Total cost	Percentage of total fuel cost
Front-end				
U_3O_8	8 kg	$45	$360	17%
conversion	7 kg U	$9	$60	3%
enrichment	4.3 SWU	$105	$450	21%
fuel fabrication			$240	11%
Total front-end			$1 110	53%
Back-end				
reprocessing			$1 000	47%
Total fuel cost			**$2 110**	**100%**

Source IPA, *Exhibit no. 48, Radioactive Waste Management in Australia*, p. 1.

12.31 The Submarine Institute of Australia (SIA) argued that by restricting industry's capacity to process uranium ore, governments not only restrict the economic return for the nation's resources, but also deny the nation the industry capability that would evolve from such activity. Moreover, as argued by the ANF and IPA above, the SIA stated that the breakdown of costs to fuel a typical light water reactor indicates that the additional three processing steps at the front-end of the fuel cycle (conversion, enrichment and fuel fabrication) represent almost half the costs to fuel the reactor—income which Australia chooses to forego:

> … by failing to take the sensible opportunity to value add, possibly by preparing fuel pellets ready for use in reactor, we deny Australia the income and the broader knowledge base of a more mature nuclear industry.[35]

12.32 Similarly, Professor Ralph Parsons, a former President of the Australian Institute of Nuclear Science and Engineering (AINSE), argued that:

> Uranium is currently mined in Australia and is exported as Yellowcake, Uranium Oxide. The nation would benefit if it were processed much further before being exported. The benefit would not only be financial but would also be in the stimulation of relatively high-technology industries.[36]

35 Rear Adm. Peter Briggs AO CSC (Retired) (SIA), *Transcript of Evidence*, 10 October 2005, p. 28; SIA, *Submission no. 21*, p. 5.

36 Professor Ralph Parsons, *Submission no. 24*, p. 1.

12.33 Professor Parsons also submitted that although much of Australia's fuel cycle expertise has been dissipated, a knowledge base to support value adding industries could once again be developed:

> Twenty five years ago there was expertise in this country in various stages of the nuclear fuel cycle, particularly in centrifuge enrichment and in the development of Synroc for waste disposal. That expertise has been dissipated but the nation now has sufficient depth of talent in Science, Engineering and Technology that the expertise could be redeveloped if there were the political will to do so.[37]

12.34 Should it be decided to establish industries along the uranium value chain in Australia, CSIRO expressed willingness to cooperate with ANSTO and industry in supporting value adding.[38]

12.35 In contrast, proposals to add value to Australia's uranium resources were rejected out of hand by individuals and groups opposed to nuclear power:

> Every time you dabble with nuclear, whether it is mining or making fuel rods or getting into enrichment—whatever it is—you are simply contributing to the global problem. There is no way around it. The only thing that you can do that is a complete safeguard is to not be involved and to do everything that you can internationally to close down the nuclear industry.[39]

12.36 The Committee now summarises three specific proposals suggested in evidence—that Australia should establish:

- a uranium enrichment industry;
- a waste disposal industry, including the operation of a geologic repository; and
- move to develop the full fuel cycle, including the 'leasing' of fuel assemblies to customer countries and the take-back of waste for final disposal.

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37 *ibid*.

38 Dr Rod Hill (CSIRO), *Transcript of Evidence*, 19 August 2006, p. 10.

39 Mr Peter Robertson (ECNT), *Transcript of Evidence*, 24 October 2005, p. 12.

Proposals

Enrichment

12.37 The Committee was pleased to receive evidence from Silex Systems Ltd (Silex), an Australian company pioneering the development and commercialisation of a laser-based, isotopic separation enrichment technology known as SILEX—separation of isotopes by laser excitation.[40] Silex is a tenant at the Lucas Heights Science and Technology Centre in Sydney.[41]

12.38 Silex began laser isotope separation research in 1990 and proved the SILEX technology on a laboratory scale in 1994. In 1996 a Licence and Development Agreement for the application of SILEX technology to uranium enrichment was signed with the US Enrichment Corporation (USEC), the largest supplier of enrichment services in the world. To facilitate the joint Silex-USEC development of SILEX technology, an Australia-US Bilateral Treaty for Nuclear Cooperation was negotiated by the respective governments in 2000. The SILEX technology was officially classified by both US and Australian Governments in 2001. In 2002 full uranium enrichment was demonstrated via direct measurement.[42]

12.39 In October 2005 the US Government approved potential commercial partners of Silex accessing classified information, which enabled prospective partners to assess the potential of the company and its SILEX process with due diligence. Several companies expressed interest in partnering with Silex in developing and commercialising the technology.[43] In May 2006 the company announced that it had entered into a technology commercialisation and license agreement for SILEX technology with General Electric (GE).[44] A test loop, pilot plant, and a full-scale commercial enrichment facility will be constructed in the US.

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40 Dr Michael Goldsworthy (Silex Systems Ltd), *Transcript of Evidence*, 9 February 2006, p. 1. As at February 2006, Silex had a market capitalisation of some $400 million and 40 employees. See also: <http://www.silex.com.au/>. In addition to uranium enrichment to produce nuclear fuel, Silex is also conducting research and development in silicon enrichment, for advanced semiconductor materials, and carbon enrichment for medical diagnostic materials.

41 Silex Systems Ltd, *Exhibit no. 87, Response to Greenpeace claims,* ASX Release, 25 November 2004, p. 1. The alleged proliferation risks associated with the SILEX technology were addressed in chapter eight.

42 Silex Systems Ltd, *Exhibit no. 88, Presentation by Dr Michael Goldsworthy*, p. 19. A history of Silex Systems' development is available online at the company's web site, viewed 8 May 2006, <http://www.silex.com.au/>.

43 Silex Systems Ltd, *Uranium Project Update*, 1 May 2006, p. 1, viewed 5 May 2006, <http://www.silex.com.au/>.

44 Silex Systems Ltd, *Silex Signs Commercialisation and License Agreement with General Electric Company for the SILEX Uranium Enrichment Technology*, 22 May 2006, p. 1, viewed 23 May 2006,

12.40 As indicated in chapter two and elsewhere in the report, uranium enrichment is a key step in the front-end of the fuel cycle and is necessary to transform uranium into a form that is useable to fuel most reactors. Following mining and milling of uranium ore, uranium oxide is first converted into a gas, uranium hexafluoride (UF_6). The enrichment process follows, in which the concentration of the fissionable isotope U-235 is increased from its natural level (assay) of 0.7 per cent to between three to five per cent.

12.41 The enrichment process produces this higher concentration of U-235 by removing over 85 per cent of the U-238. This is done by separating the gaseous UF_6 into two streams, one being enriched to the required level and known as low-enriched uranium (LEU). The other stream is depleted in U-235 and is called 'tails'. Having been enriched, the gas is then reconverted to produce enriched uranium oxide, which is then fabricated into pellets and finally assembled into tubes, or fuel elements. Bundles of the tubes are inserted into a nuclear reactor core to produce the heat required to make steam and drive the turbines which generate electricity.

12.42 There are currently two enrichment technologies in large scale commercial use: gaseous diffusion, which is the oldest enrichment technology and referred to by Silex as 'first generation'; and gas centrifuge enrichment, a 'second generation' technology. It was explained that both of these technologies have significant drawbacks. Diffusion plants have very high operating costs, produce low enrichment levels, are very inefficient and consume large amounts of electricity. Centrifuge plants have very high capital costs, but consume less energy than diffusion plants. Both technologies are massive, requiring tens of acres each to deploy.[45]

12.43 The output of enrichment plants is referred to as separative work units (SWUs) and Silex stated that some 40 million SWUs are currently produced annually in the uranium enrichment market worldwide.[46] One SWU is currently valued at US$115. Enrichment costs are substantially related to electrical energy used. The gaseous diffusion process consumes

<http://www.silex.com.au/public/uploads/announce/Silex-GE%20Agreement%20ASX%200506%20Final.pdf>. See also: General Electric, *GE Signs Agreement with Silex Systems of Australia to Develop Uranium Enrichment Technology; Move Would Expand GE's Presence Within Global Nuclear Sector*, Press Release, 22 May 2006, viewed 23 May 2006, <http://www.ge.com/en/company/news/index.htm>.

45 Dr Michael Goldsworthy, *op. cit.*, pp. 9–10.

46 *ibid.*, p. 6. See also World Nuclear Association (WNA), *The Global Nuclear Fuel Market*, WNA, London, 2005, pp. 151–158.

about 2 500 kWh per SWU, while gas centrifuge plants require about 50 kWh per SWU.[47]

12.44 In contrast to the existing enrichment technologies, SILEX is a laser based rather than mechanical process. While the precise numbers are classified, the SILEX enrichment efficiency is said to far exceed that of the existing technologies.[48] Key features of the technology are that it has very low energy requirements and much lower capital costs. Table 12.2 compares the existing technologies with the SILEX technology.

Table 12.2 SILEX v existing technologies

	SILEX	Gas Centrifuge	Gaseous diffusion
Developed	2000s	1940s	1940s
Process	Laser excitation	Mechanical (‘centrifugal force’)	Mechanical (‘brute force’)
Enrichment efficiency	2 to 20[1]	1.25	1.004
Estimated cost per unit (US$)	\$30~\$40[2]	\$60~\$80	~\$100
% of existing market[3]	0%	40%	45%
Status	Under development 3rd Generation	Proven 2nd Generation	Obsolete 1st Generation

Source Silex Systems Ltd, *Exhibit no. 88, Presentation by Dr Michael Goldsworthy*, p. 17.
[1] Classified
[2] Indicative estimate only—needs to be verified in Pilot Program
[3] Approximately 15% of market currently supplied via Russian HEU material

12.45 As noted above, it was emphasised that enrichment is central to nuclear economics. Silex argued that nuclear fuel costs represent some 30 per cent of the total costs of nuclear power, with an approximate breakdown of the components of the fuel costs listed in table 12.3. While there is variation over time, uranium ore accounts for approximately 35 per cent of the costs of the fuel, while enrichment accounts for about 40 per cent and fuel fabrication some 20 per cent.[49] The ANF also noted that enrichment and fuel fabrication contribute some 41 per cent and 22 per cent of the total nuclear fuel cost respectively.[50]

47 WNA, *Uranium Enrichment*, WNA, London, March 2006, viewed 8 May 2006, <http://world-nuclear.org/info/inf28.htm>.

48 Dr Michael Goldsworthy, *op. cit.*, p. 10.

49 *ibid.*, p. 6.

50 ANF, *Exhibit no. 4, loc. cit.*

Table 12.3 Nuclear fuel costs—percentage of total

Stage of front end of cycle	Percentage of total
Uranium ore	~35%
Conversion (to UF_6)	~5%
Enrichment	~40%
Fuel fabrication	~20%

Source Silex Systems Ltd, *Exhibit no. 88, Presentation by Dr Michael Goldsworthy*, p. 13.

12.46 As the price of uranium rises, demand for enrichment services increases. As Silex explained:

> By increasing the level of enrichment to produce lower tails assay, this also decreases the amount of ore consumed. So you can extract more from the same kilogram of uranium by increasing the enrichment and throw away less. This has an impact on increasing uranium prices and an increase in enrichment services.[51]

12.47 Silex suggested that its technology is so efficient that it may even be possible to take the waste stream from previously enriched uranium (i.e. the tails) and re-enrich it:

> … our process is looking so efficient that we might be able to re-enrich a lot of the stockpiled tails from the last 30 or 40 years of enrichment that are still sitting there. These have only been stripped from 0.7 per cent to 0.4 per cent or 0.35 per cent. They have had only half of the good stuff taken out because uranium was so cheap. Now that uranium is becoming more expensive and our technology means it is half the cost to enrich, you might have a secondary source of uranium. We could go and re-enrich the tails back up to natural uranium or continue. So there is a real dynamic between enrichment and uranium.[52]

12.48 The outlook for enrichment services published recently by the World Nuclear Association (WNA) predicts growth in its reference case. Based on the WNAs uranium enrichment market outlook, Silex has estimated the value of the market in the years ahead. In 2006 the enrichment market was estimated to be worth US$5 billion and is projected to be worth $17 billion by 2025, assuming growth corresponding to the WNA's reference case for world enrichment requirements.[53]

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51 Dr Michael Goldsworthy, *op. cit.*, p. 6.

52 *ibid.*, p. 11.

53 Silex System Ltd, *Exhibit no. 88, Presentation by Dr Michael Goldsworthy*, p. 15; WNA, *The Global Nuclear Fuel Market: Supply and Demand 2005–2030*, WNA, London, 2005, p. 93.

12.49 Silex described what Australia could potentially earn if the nation were to enrich about the same proportion of uranium that it currently exports as uranium oxide:

> If we translate that to the Australian situation, where we do not enrich uranium—we let everyone else make this money at our expense—in 2015, if we assume we are providing about one-third of the world's uranium, the value of enrichment that we could achieve by enriching here in Australia is about $US3 billion a year. By 2025, if we enriched that one-third share here in Australia instead of sending it overseas, that number increases to about $US6 billion or $A8 billion. That is the lost opportunity to Australia from not enriching here in Australia.[54]

12.50 In short, the value added by enriching uranium in Australia could potentially be approximately A$8 billion per year by 2025. However, with the restrictions on enrichment in Australia, Silex explained that its intention is to take the technology to the US and have a royalty stream coming back to Australia:

> Our preference would be to do it here and make all the money, but I do not think that is going to happen in my lifetime. So we are going to have a relationship with an American company or two … and have a royalty stream coming back to Australia on our technology.[55]

12.51 In terms of the supply and demand balance, Silex emphasised that there is no overcapacity in the enrichment services industry and demand exists for new entrants over the next 10 to 20 years. It was argued that with the continued operation of two older gaseous diffusion enrichment plants (one in France owned by Areva and another in the US, owned by USEC) a balance exists between supply and demand for enrichment services at present. However, the two diffusion plants, constructed in the 1950s and 1960s, are scheduled to be closed.

12.52 By 2010, even allowing for the planned construction of three of the newer centrifuge plants, one in France (by Areva) and two in the US (by USEC and the US National Enrichment Facility (NEF)), Silex argued that there will be a supply deficit of up to 13 million SWU. If there is no other source of supply, Areva and USEC will be forced to keep their older gaseous diffusion plants in operation beyond 2010. However, it is estimated that by 2015 the supply deficit will have grown to 27 per cent of demand, or 15

54 *Dr Michael Goldsworthy, op. cit.*, p. 7.

55 *ibid.*, p. 8.

million SWU. The implication of these forecasts, which are listed in table 12.4, is that there *is* a place in the market for the SILEX technology:

> It takes 10 years to build any of these plants, and it will take us 10 years to get to a commercial position. So we need to look this far out. Already you can see a very big supply deficit emerging over the next 10 years. This is the industry. People who say there is an overcapacity are kidding themselves.[56]

Table 12.4 Uranium enrichment market outlook—supply and demand forecasts

Supplier	2005		2010		2015	
	MSWU	%	MSWU	%	MSWU	%
AREVA (GD)	9	20	?	-	0	-
USEC (GD)	7	16	?	-	0	-
USEC (HEU)	6	13*	6	12	0	-
URENCO (C)	7.5	17	9	18	10	18
TENEX (C)	12	26	12	24	12	12
AREVA (C)	0	-	2	4	7.5	13
USEC (C)	0	-	2	4	3.5	6
NEF (C)	0	-	2	4	3	5
OTHER (C)	3.5	8	4	8	5	9
SUPPLY	45	100	37	74	41	73
DEMAND	45		50		56	
DEFICIT	***0***	***0***	***13***	***26%***	***15***	***27%***

Source Silex System Ltd, *Exhibit no. 88, Presentation by Dr Michael Goldsworthy*, p. 16.
Notes:
MSWU = Million separative work units
GD = Gaseous diffusion
HEU = Highly enriched uranium
C = Gas centrifuge
* Russian HEU material provided to the US

12.53 The Committee notes, however, that in its forecast of supply and demand in the nuclear fuel market over the period to 2030, the WNA concludes that:

> Given the modular expansion capability of gaseous centrifuge designs and the required timelines for building new nuclear plants, capacity in the enrichment sector of the fuel cycle should be able to meet the requirements of the worldwide commercial nuclear fleet under any current projection of demand.[57]

56 *ibid.*, p. 9.
57 WNA, *op. cit.*, p. 157.

12.54 Appendix H lists the world's uranium enrichment plants, their status (operable, under construction or decommissioned), the technology employed, operator, nameplate capacity, annual production, year of start up of commercial operation/proposed date, and date of shutdown.

12.55 It was noted that the SILEX technology is the sole surviving laser enrichment technology in the world. A range of Governments, including the US, Japan, Britain, France and Germany, have previously attempted to build laser enrichment technologies and all have failed. However, Silex expressed confidence in its prospects of commercial success, arguing that its approach is quite different to those attempted by these governments. In particular, Silex claims to have viable engineering concepts and its technology can be industrialised.[58]

12.56 The company has also commenced preliminary activities in the next phase of its Technology Development Program—the Test Loop Program. The objective of the Test Loop Program is to demonstrate efficient enrichment in plant-scale prototype facilities, and to accurately measure process efficiency and evaluate economics. This program is expected to take up to two and a half years to complete.[59]

12.57 Silex advised that it will take the company some six or seven years to produce commercial material at a pilot level and another three to four years before industrial level production could occur. A commercial plant could be operational in 2013, with a small scale plant costing in the order of A$500 million to construct.[60] However, the company expressed confidence about the potential for the technology's commercial development:

> … Silex is well positioned to capitalise on the impending increase in the demand for new enrichment capacity, and the need to replace the aging gaseous diffusion capacity still in use today. If the economics of the SILEX process prove to be as attractive as we anticipate, our technology will become a major player in the uranium enrichment industry.[61]

12.58 The ANF and others also argued that, consistent with International Atomic Energy Agency (IAEA) proposals (described in chapter seven) for the establishment of any future fuel cycle facilities under multinational

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58 Dr Michael Goldsworthy, *op. cit.*, p. 10.

59 Silex Systems Ltd, *Project and Operational Update*, ASX Announcement, 15 March 2006, p. 2, viewed 5 May 2006, <http://www.silex.com.au/>.

60 Dr Michael Goldsworthy, *op. cit.*, p. 14. The same capacity centrifuge plant would cost in the order of three times this amount.

61 Silex Systems Ltd, *Project and Operational Update*, ASX Announcement, 15 March 2006, p. 1, viewed 5 May 2006, <http://www.silex.com.au/>.

control, 'Australia might be an ideal location for at least a fuel enrichment plant under multinational safeguards control.'[62]

Nuclear waste disposal

12.59 Nova Energy argued that Australian industry and Government should develop a position on the storage and disposal of nuclear waste in Australia:

> I think there is a responsibility as part of the overall debate about uranium mining to have a clear position, as an industry and as a government, as to whether it is acceptable in the community to ultimately store [nuclear waste] material, but I think we are obligated to have resolved those issues before mining occurs, whether storage is ultimately in Australia or elsewhere.[63]

12.60 Similarly, Arafura Resources and the CSIRO argued that Australia should develop a policy that outlines the stewardship issues and conditions of product ownership associated with uranium supply, usage, and disposal.[64]

12.61 A number of submitters expressed support for establishing a nuclear waste disposal industry in Australia and constructing a high-level waste repository. It was emphasised that Australia has suitable geology to host a repository and a waste disposal industry would be highly profitable. For example:

- Silex submitted that:

> … it would be fantastic to see Australia playing a role in every step of the fuel cycle. Not only that, there is a waste industry out there waiting to happen, of nuclear waste being stored around the world, which amounts to hundreds of billions of dollars. It is waiting for someone to come along and do it. The waste industry itself is a huge economic resource.[65]

- Southern Gold stated that it:

> … firmly believes that suitable repository sites exist within stable geological environments within Australia and that Australia must

62 ANF, *Submission no. 11, loc. cit.*

63 Mr Richard Pearce (Nova Energy Ltd), *Transcript of Evidence*, 23 September 2005, p. 80.

64 Arafura Resources NL, *Submission no. 22*, p. 10; CSIRO, *Submission no. 37*, pp. 8–9. See also: Minerals Council of Australia, *Submission no. 36*, pp. 19–20.

65 Dr Michael Goldsworthy, *op. cit.*, p. 20.

> take advantage of the economic benefits of storing small quantities of high-level nuclear waste.[66]

- AINSE submitted that:

> Because of the stable geological nature of the Australian mainland there may be good business opportunities associated with the storage and handling of nuclear waste.[67]

12.62 As mentioned in chapter five, Dr Ian Smith, Executive Director of ANSTO, argued that 'Australia has some of the best geology in the world' for a repository and that 'there are hundreds of sites in Australia which would be suitable for that purpose.'[68]

12.63 Arafura Resources emphasised Australia's geological suitability and the global security benefits of Australia conducting waste disposal:

> Australia … has ideal waste storage locations given the geological stability of many areas, large areas of ideal host rocks, and the remoteness of many locations from large populations. Deep burial in dry stable rock is the ideal location for radioactive storage as the product can naturally decay without causing any harmful effects on the environment. With a product as sensitive as radioactive waste, Australia could be the best place for waste storage given our ideal geological locations, political stability and responsible attitudes. It will be safe from illegitimate use if it is stored in Australia. The community has a right to know that nuclear waste can be safely disposed of.[69]

12.64 Arafura also argued that Australia 'could become a leader in safe secure disposal' of nuclear waste and that the nation should now identify strategic waste disposal locations.[70]

12.65 The Institute of Public Affairs (IPA) likewise submitted that:

> Australia may be in a unique position to offer safe long term burial of waste. This will not only make a substantial contribution to world security but also offer a very large business opportunity.[71]

12.66 The IPA argued that Australia, along with Namibia/South Africa, the Terim Basin in China and southern Argentina have potential disposal sites whose geological properties would intrinsically provide reliable long-term containment for nuclear waste. These sites would meet the geological

66 Southern Gold Ltd, *Submission no. 54*, p. 10.
67 AINSE, *Submission no. 77*, p. 2.
68 Dr Ian Smith (ANSTO), *Transcript of Evidence*, 13 October 2005, p. 15.
69 Arafura Resources NL, *Submission no. 22*, p. 6.
70 *ibid.*, p. 10.
71 IPA, *Exhibit no. 48, Radioactive Waste Management in Australia*, p. 1.

characteristics required of a so-called 'high-isolation site' such as minimal groundwater flow, maximum time for any waste to reach the biosphere, minimal possibility of human exposure, and long-term stability in climate and geology.[72]

12.67 It was noted that in addition to the geological requirements, there are a number of non-geological criteria that limit even further the number of possible locations for a repository. These criteria include suitable transportation corridors, political stability, and national institutions and technology capable of overseeing the repository's safe development and operation. The IPA argued that after considering all such criteria, truly ideal high-isolation sites are in fact very rare.[73]

12.68 The IPA argued that Australia should offer to dispose of the wastes generated from the uranium supplied from Australian mines in the first instance, and then consider the disposal of wastes from the Asian region where countries are unlikely to find secure high-isolation sites. Based on an industry price estimate of $1 million per tonne of spent fuel (which corresponds to a cost of approximately 0.4 cents/kWh for a light water reactor), it was argued that even restricting storage to Australian-sourced uranium would make for a substantial market of 1 000 to 2 000 tonnes of spent fuel annually—that is, revenues of $1–2 billion annually for disposal of Australian-sourced uranium alone.[74] As noted in chapter five, 12 000 tonnes of spent fuel is discharged annually worldwide, and there is currently a global inventory of some 270 000 tonnes of spent fuel and its derivatives in interim storage.[75]

12.69 In summary, the IPA argued that:

> The disposal of spent fuel and high-level waste in Australia is a major opportunity. It would not only be a significant business opportunity, but also a major enabling step for the use of nuclear power, an important contribution to nuclear safety, and a major contribution to our region.[76]

12.70 Areva and Arafura Resources also suggested that Australia should take back the waste produced in nuclear reactors using Australian uranium.[77]

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72 *ibid.*, pp. 6, 8.

73 IPA, *Exhibit no. 47, The Safe Disposal of Nuclear Waste*, p. 3.

74 *ibid.*

75 IPA, *Exhibit no. 48, op. cit.*, p. 10.

76 IPA, *Exhibit no. 47, loc. cit.*

77 Mr Stephen Mann (Areva), *Transcript of Evidence*, 23 September 2005, p. 11; Mr Alistair Stephens (Arafura Resources NL), *Transcript of Evidence*, 23 September 2005, p. 52.

12.71 Mr John Reynolds, formerly the Chairman of the Uranium Information Centre, submitted that, given the vast area of remote and geologically stable terrain in Australia, it would be readily achievable to site a repository in Australia from a technical and safety view point. However, it was argued that:

> The problems lie in the politics of location as already shown in the unfortunate failure to determine a location for a national repository for low level medical … wastes, whose risk to public safety … was in reality virtually non-existent.
>
> Our failure is essentially because subjective political action has frustrated real understanding of the risks and benefits of establishing an engineered repository.[78]

12.72 While accepting that 'this is politically the most difficult area', Professor Leslie Kemeny argued that Australia should accept nuclear waste from other countries:

> I believe Australia, as a potential major supplier of uranium to an energy hungry world should take on this responsibility as financially lucrative, as a sunshine industry and as a place which is geologically and in every way suitable for acceptance of so-called nuclear waste.[79]

12.73 Other submitters, particularly those critical of nuclear power, argued that if Australia permits uranium mining, then Australia should also be responsible for the nuclear waste which results from its use.[80]

12.74 While AMEC doubted whether Australia had a 'moral' obligation to dispose of nuclear waste generated from the use of Australian uranium, it also argued that 'there is a wonderful opportunity for Australia to capture the ability to dispose of radioactive waste in this country and to do it safely.'[81]

12.75 The Northern Territory Minerals Council (NTMC) also questioned whether Australia has an obligation to accept nuclear waste and suggested that such considerations should be conducted on economic grounds alone:

> In terms of the proposition of taking back nuclear waste, that should be viewed as an economic rather than a moral decision. I do not think that it follows, as some have said, that because we produce uranium we have a moral obligation to take back spent fuel rods and the like. The vast quantity of economic benefit is

78 Mr John O Reynolds, *Submission no. 5*, p. 6.

79 Professor Leslie Kemeny, *Transcript of Evidence*, 16 September 2005, pp. 93–94.

80 See for example: Ms Janet Marsh, *Submission no. 2*, p. 3.

81 Dr David Blight (AMEC), *Transcript of Evidence*, 23 September 2005, p. 17.

> derived by those producing power and selling it down the track. The percentage we derive from selling the product is minuscule. If it makes economic sense, by all means look at it on that economic and scientific basis, but I do not think there is a moral obligation to do it.[82]

12.76 In relation to the commercial prospects for the Australian synthetic rock (Synroc) waste technology, described in chapter five, ANSTO commented that 'synroc has been identified internationally … as being the disposal route of choice for plutonium-contaminated material.'[83] ANSTO is currently building a pilot plant with the British Nuclear Group to process waste material contaminated with plutonium, as part of the clean-up of the Sellafield site in England. ANSTO is also pursuing the opportunity of having Synroc used for three sites in the US which have similarly large clean-up programs.

12.77 The ANF and Arafura Resources argued that ANSTO certainly has expertise in waste disposal and that Synroc is the best technology available, but noted that it may be more expensive than the glass alternative. In terms of its capabilities, it was observed that Synroc 'is much more than is really required.'[84] Other countries are said to have made considerable investments in other waste forms that they are unlikely to abandon in favour of Synroc:

> Although it will find a place in the future for special applications, Australia should remember that both Britain and France have the equivalent of about a £5 billion investment in their present way of doing things, and they are certainly not going to just shut that down so they can embrace synroc. There will come a time when the plant becomes obsolete, and that will be the time when these people will be making decisions about synroc. However, if we were to use one of the processes in Australia, synroc is probably the one we would choose.[85]

Synroc is being considered for use in the UK to immobilise five tonnes of intractable plutonium waste that cannot be reprocessed economically.[86]

12.78 AINSE argued that there is accelerator/reactor-driven waste destruction research underway in several countries, notably in Japan (at J-PARC), the US and France. As described in chapter five, some of this research is aimed

82 Mr Ian Henwood (NTMC), *Transcript of Evidence*, 24 October 2005, p. 39.

83 Dr Ian Smith (ANSTO), *Transcript of Evidence*, 13 October 2005, p. 17.

84 Dr Philip Moore (ANF), *Transcript of Evidence*, 16 September 2005, p. 48.

85 *ibid*.

86 *ibid*.

at reducing the activity of highly radioactive isotopes by a factor of 100, thereby reducing the required storage time of waste from thousands to a few hundred years. AINSE argued that if the Australian Government decides to become involved in the beneficiation of nuclear waste through the development of waste storage solutions, then it should offer to participate in these transmutation research programs. If storage solutions were developed in conjunction with J-PARC technology, the industry could also involve strategic alliances for Australia.[87]

12.79 The CSIRO submitted that it also has expertise in the area of radioactive waste management and could contribute in areas complementary to ANSTO's existing technology capabilities, such as:

- material development to increase the lifetime and performance of materials of construction and containment used in the nuclear industry;
- chemical processing to reduce the escape of certain waste forms into the environment;
- the customisation of the properties of zeolite materials used for the capture and retention of radioactive organic species that may not have high levels of sorption onto clay and rock surfaces used traditionally for containment materials;
- more efficient and effective handling systems to promote the ability of disposing of radioactive wastes;
- integrated modelling of fluid flow and solute transport to allow development of more effective management systems and better understanding of geotechnical impacts and two phase gas migration;
- linking physical models of groundwater flow and radionuclide transport to biosphere models of plant uptake and human ingestion; and
- linking process models to risk models.[88]

12.80 In the context of the issue of siting a Commonwealth radioactive waste repository in the Northern Territory, the Northern Land Council submitted that there is potential for Australia to develop world's best practice in nuclear waste management:

> In terms of world's best practice, we believe that the Northern Territory Department of Minerals and Energy could actually deal

87 AINSE, *loc. cit.*

88 CSIRO, *Submission no. 37*, p. 9.

> itself into a sphere of excellence in mining and in nuclear waste repositories that would set Australia apart.[89]

A 'Nuclear Fuel Cycle Complex' and fuel leasing

12.81 The Australian Nuclear Association (ANA) proposed the eventual development of a 'cradle to grave' concept for Australia's uranium, which would involve the construction of an 'Integrated Nuclear Fuel Cycle Complex' (NFC Complex) in Australia. The concept would:

> … take Australia's uranium through the front end of the nuclear fuel cycle to the production of fuel elements which would be leased to overseas nuclear power programs. The spent fuel would be returned to Australia, stored, reprocessed and the unused uranium and plutonium recycled into MOX fuel for lease to overseas nuclear plants. The high level waste would be converted into Synroc and placed in a deep repository in the most suitable part of Australia.[90]

12.82 The ANA argued that this approach, which would involve the gradual establishment of facilities on a stage by stage basis, would 'place Australia at the leading edge of the nuclear industry, earn enormous export revenue and contribute significantly to the world's non-proliferation needs.'[91] Moreover, the project would involve a huge investment of capital, technology and a skilled workforce. In short, it would be 'the 21st Century equivalent of the Snowy Mountains Scheme.'[92]

12.83 The benefits of an integrated NFC Complex were said to include:

- less transport distance and time between fuel cycle stages with lower cost;
- less risk of loss of valuable material by accident and access by terrorists;
- easier control by regulatory agencies responsible for non-proliferation;
- multi-national or international involvement with greater transparency;
- less or no need for small countries to invest in their own expensive and politically sensitive facilities provided they are guaranteed supply.[93]

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89 Mr Norman Fry (NLC), *Transcript of Evidence*, 24 October 2005, p. 22. See also: NLC, *Submission no. 78*, p. 6.

90 Mr Robert Gishubl, *Exhibit no. 90*, *A Cradle to Grave Concept for Australian Uranium*, by Dr Clarence J Hardy, p. i.

91 *ibid*.

92 *ibid*.

93 *ibid*., p. 2.

12.84 Based on WNA projections for demand and supply of fuel cycle services, and reinforcing the claims made by Silex, the ANA concluded that current conversion and enrichment capacity is sufficient to meet current demand, but there will be insufficient capacity in these industries by 2010 due to the risk of new capacity not coming online, especially in the US. It was argued that:

> … this presents a window of opportunity for an Australian NFC Complex, starting with conversion and enrichment and then adding fuel fabrication and finally reprocessing and waste management.[94]

12.85 Even if the WNA's 'business as usual' scenario eventuates, in which nuclear capacity increases only modestly over the period to 2030, the ANA argued that:

> … there will be a substantial increase in requirements for uranium and fuel cycle services including conversion, enrichment, fuel fabrication, reprocessing, recycle of recovered uranium and plutonium, and waste management facilities. There is a very good opportunity to design and construct multi-national or international fuel cycle centres. These offer technical, economic and non-proliferation advantages.[95]

12.86 Nova Energy also expressed support for the eventual development of advanced nuclear industries in Australia, which would commence with uranium enrichment and eventually involve the fabrication and return of used fuel rods:

> The idea of producing U_3O_8 concentrates … and having a high-tech, high-value industry that enriches uranium in Australia, exports fuel rods and then brings back those fuel rods to Australia for re-treatment and/or storage strikes me as ultimately a very advanced, high-tech, high-value and responsible industry for Australia to head towards.[96]

12.87 Similarly, Professor Leslie Kemeny submitted that:

> A dominant supplier of uranium—such as Australia—should capitalise on both the front and the rear end of the global fuel cycle by enriching the mined product, fabricating the fuel, leasing it to trading parties and disposing in suitable waste repositories. The return on the front and rear end processing costs of around $1500

94 *ibid.*, p. 6.

95 *ibid.*, p. 11.

96 Dr Timothy Sugden (Nova Energy Ltd), *Transcript of Evidence*, 23 September 2005, p. 73.

> (Aus) per kilo each can thereby be optimised and the proliferation and safeguards risks minimised.[97]

12.88 Although personally opposed to the concept of fuel leasing because of alleged weaknesses in the international safeguards regime, Professor Richard Broinowski argued that the concept of fuel leasing has merit:

> We are selling yellowcake. Yellowcake is the lowest form of beneficiation of uranium. Enormous value could be added to it if we had even a uranium hexafluoride [conversion] plant, if we could fabricate it into fuel rods and if we could lease the rods, not sell them—this was put twice to the Fraser government as something we should seriously do, and they turned it back … if we had the whole cycle and we bought back, as a morally conscientious people should, the spent fuel that we have so happily sold to the world—we could have developed a very important and powerful industry here in Australia. That would give us a greater say in the international community about nuclear matters …[98]

12.89 Southern Gold also supported the concept of developing other fuel cycle industries so that Australia can both manufacture nuclear fuel and then receive back the waste products for storage and final disposal. The benefits were said to include the substantial profits that could be earned and greater control over the fuel cycle, thereby reducing proliferation risks.[99]

12.90 However, the Committee notes that the Australian Safeguards and Non-Proliferation Office (ASNO) is critical of the fuel leasing proposal. ASNO's submission to the Prime Minister's Nuclear Energy Review sets out the following objections:

- the fuel leasing proposal implies, incorrectly, that Australia's current safeguards are deficient and fails to address the real proliferation risk, which is said to be the detection of clandestine and undeclared nuclear activities (e.g. Iraq, DPRK, Libya and Iran), particularly undeclared centrifuge enrichment;
- the proposal is unrealistic (e.g. it would not be practicable for Australia to manufacture fuel assemblies for all Australia's uranium customers—some 60 different reactor models in total) and would involve other

97 Professor Leslie Kemeny, *Submission no. 64*, p. 5.
98 Professor Richard Broinowski, *Transcript of Evidence*, 16 September 2005, pp. 19–20.
99 Mr Ric Horn (Southern Gold Ltd), *Transcript of Evidence*, 19 August 2005, p. 15.

major practical issues such as cost, infrastructure, availability of experienced workforce, and substantial lead-times; and

- it fails to recognise major changes taking place on spent fuel management, notably the move away from currently established PUREX technology to the concept proposed for the US GNEP initiative, in which plutonium will be recycled without first separating this material from uranium, minor actinides and some fission products (thereby reducing the proliferation and terrorism risks).[100]

12.91 The Committee concludes that as a country possessing some 40 per cent—and potentially more—of the world's uranium resources, Australia has always had an extremely strong economic interest in, and justification for, seeking to add value to its uranium resources prior to export. By repeatedly preventing the establishment of such facilities, such as uranium conversion and enrichment, Australia has foregone considerable additional export revenues, the development of sophisticated technologies and expanded national skills and expertise.

12.92 The Committee has no in-principle objection to Australia developing domestic fuel cycle services industries. Indeed, as argued by some submitters, fuel cycle facilities could well be established in Australia on a joint ownership, co-management or drawing rights basis, in accordance with the IAEA's expert advisory group recommendations outlined in chapter seven, thereby providing a high level of transparency for regional neighbours and the international community generally. Such a development would have clear global non-proliferation benefits, while also allowing Australia the opportunity to extract greater returns from its immense uranium resource endowment, to develop sophisticated technologies and to expand its national skills base.

12.93 The Committee also notes evidence that Australia possesses ideal locations for a geologic repository to dispose of nuclear waste and that, again, a waste management industry could be of immense economic value to the nation. Such a development could also involve the development of sophisticated technologies and skills. Operation of such a facility in Australia could also have global non-proliferation benefits. Australia already holds considerable expertise in the immobilisation of high level waste through the Synroc technology.

12.94 The Committee recognises that prior to such facilities being established in Australia, governments would first need to develop an appropriate

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100 Mr John Carlson, Director General, ASNO, submission to the *Uranium Mining, Processing and Nuclear Energy Review*, p. 30, viewed 16 October 2006, <http://www.pmc.gov.au/umpner/submissions/77_sub_umpner.pdf>.

licensing and regulatory framework, and remove legislative prohibitions on the establishment of such facilities.

Recommendation 12

The Committee recommends that the Australian and state governments, through the Council of Australian Governments:

- **examine how Australia might seek greater beneficiation of its uranium resources prior to export and encourage such a development, while meeting non-proliferation objectives proposed in initiatives such as the US Global Nuclear Energy Partnership (GNEP) and the International Atomic Energy Agency's (IAEA) proposed multilateral approaches to the nuclear fuel cycle;**
- **examine the possible establishment of fuel cycle facilities (for example, uranium conversion and enrichment plants) which, in accordance with the IAEA's recommendation for such facilities to be operated on a multilateral basis, could be operated on a joint ownership, co-management or drawing rights basis with countries in the region intending to use nuclear energy in the future;**
- **examine whether, in light of the advances in spent fuel management proposed in the GNEP initiative, there is in fact a potential role for Australia in the back-end of the fuel cycle;**
- **in the event these proposals are adopted, develop a licensing and regulatory framework, that meets world's best practice, to provide for the possible establishment of fuel cycle services industries and facilities in Australia; and**
- **having established an appropriate regulatory regime, remove legislative impediments to the establishment of nuclear fuel cycle facilities in Australia and, specifically, repeal or amend:**
  - ⇒ **Section 140A of the *Environment Protection and Biodiversity Conservation Act 1999*, and**
  - ⇒ **Section 10 of the *Australian Radiation Protection and Nuclear Safety Act 1998.***

The Committee further recommends that such examination take account of full life cycle costs and benefits of the proposed facilities.

Domestic use of nuclear power

12.95 Several submitters called either for the introduction of nuclear power in Australia or for the issue to at least be thoroughly examined. AMEC argued that 'the future adoption of nuclear energy will allow Australia to effectively contribute to the consistent global reduction of greenhouse gas emissions' and recommended that 'the question of nuclear energy being used as an electricity supply option in Australia be constantly reviewed.'[101]

12.96 Mr John Reynolds submitted that:

> In its own interests and as a contribution to the containment of greenhouse gas emissions globally, there is a strategic, economic and ethical case for Australia now, to include nuclear electricity generation in its energy infrastructure.[102]

12.97 Mr Barry Morgan was direct in his submission to the Committee:

> For heavens sake stop messing around with enquiries etc and get on with not only opening up more mines but actually building our own reactors and developing clean pollution free electricity generation.[103]

12.98 However, Mr Keith Alder argued that even if there were bipartisan support it could take 12 to 15 years before a nuclear power station would be operating in Australia. The reason given for this was that a first reactor in a new country would take longer because of the regulation and licensing procedures that would first need to be established. It was estimated that construction time would be not less than six years.[104]

12.99 Mr Reynolds argued that there would be a number of advantages to the nation from the use of nuclear power, beyond its environmental merits, its contribution to global greenhouse gas mission abatement and the security of fuel supply from domestic resources that it offers:

- it would enhance Australia's credibility in the global uranium trade and help secure a long term and beneficial participation in the nuclear fuel market;

101 Mr Alan Layton (AMEC), *Transcript of Evidence*, 23 September 2005, p. 13. See for example: Mr Robert Elliott, *Submission no. 1*, p. 1.

102 Mr John O Reynolds, *op. cit.*, p. 4.

103 Mr Barry Morgan, *Submission no. 68*, p. 1.

104 Mr Keith Alder, *Transcript of Evidence*, *op. cit.*, p. 91.

- it would provide a new dimension of technology in Australia, in which education and technical institutions would participate with great benefit;
- it would provide new and challenging opportunities to the manufacturing and service industries;
- new skilled and professional employment opportunities and career paths would be generated;
- it would stimulate possible adoption of down-stream industries such as uranium conversion (to UF_6), enrichment to fuel grade, and possibly fuel manufacture; and
- it could offer an opportunity for Australia to become a world nuclear fuel provider in the longer term with the further possibility of offering fuel reprocessing and storage services. These would be most valuable industries and would strengthen Australia's already respected efforts in supporting the international instruments against proliferation of nuclear weapons.[105]

12.100 In addition, Mr Reynolds argued that in the longer term it can be expected that hydrogen will be used a substitute for present transport fuels. It was claimed that research suggests that nuclear energy may well become a basis for the production of hydrogen using high temperature reactor technologies, thereby reducing greenhouse gas emissions from the transport sector.[106]

12.101 Professor Leslie Kemeny also argued that 'we should accept nuclear power as a mature technology, legitimate for Australia's use.'[107] Professor Kemeny also argued that Australia has not necessarily lost time in delaying adopting nuclear power because of the evolution of reactor designs. For example, it was noted that Generation IV reactor designs will be suitable for electricity generation, producing potable water by desalination and, as noted by Mr Reynolds, for the production of hydrogen for transportation.[108]

12.102 Several submitters, including AMEC, the Australian Academy of Technological Sciences and Engineering (AATSE), Mr Keith Alder and others, called for an examination of the use of nuclear power in the

105 Mr John O Reynolds, *op. cit.*, p. 7.

106 *ibid.*

107 Professor Leslie Kemeny, *Transcript of Evidence*, *op. cit.*, p. 93.

108 *ibid.*, p. 97.

Australian context, and particularly for a thorough investigation of the economic viability of a domestic nuclear power industry.[109]

12.103 Other submitters, including the IPA and AMP CISFT submitted that nuclear power will not be competitive in the domestic context due to Australia's vast endowment of low-cost, high-quality coal resources.[110]

12.104 The IPA argued that estimates for the generation costs of nuclear power plants in Australia vary from the low $50s to the upper $60s per MWh, while coal in Eastern Australia costs under $40/MWh and natural gas is $44/MWh. These estimates exclude taxes, subsidies and other regulations designed to alter the choice of power generation technologies. Thus, it was concluded that:

> As it is 30–60 per cent more expensive than coal-generation, and somewhat more costly than gas, in the absence of government intervention, nuclear does not have a future in Australia in the medium-to-long term. Nuclear is, on the other hand, significantly more cost effective than wind and all other exotic alternatives.[111]

12.105 However, the IPA noted that if an EU-type Greenhouse Gas Emission Trading Scheme were established in Australia (thereby increasing the costs of carbon emissions) this would significantly alter the cost ranking of the various power generation technologies in Australia. It was argued that if the current EU carbon price (presently trading at around €16 per tonne CO_2) were to emerge from a carbon trading scheme in Australia, nuclear power would be the lowest cost source of future energy in Australia.[112]

12.106 It was submitted that if Australian governments were to require a 60 per cent reduction in the country's greenhouse gas emissions, nuclear power would need to play a major role:

> Indeed, it is difficult to envisage how a 60 per cent reduction target can be achieved other than by all, future, large base-load power stations being nuclear.
>
> Such a policy would need to effected by a carbon tax or a system of vesting tradeable rights to carbon dioxide emissions.[113]

12.107 The IPA emphasised, however, that it strongly opposes the establishment of a carbon trading scheme, arguing that it would increase electricity and

109 See: AATSE, *Submission no.3*, p. 1; Mr Keith Alder, *Submission no. 7*, p. 4; Mr John O Reynolds, *op. cit*., p. 6; AMEC, *op. cit*., p. 6.

110 See: IPA, *Exhibit no. 46, The Economics of Nuclear Power*, p. 1; AMP CISFT, *Submission no. 60*, p. 7.

111 IPA, *ibid*.

112 *ibid*., p. 2.

113 *ibid*., p. 3.

gas prices by at least 50 per cent and would be accompanied by a considerable loss of wealth through 'writing off the value' of Australia's brown and black coal resources. A secondary implication could be the nation's loss of comparative advantage in raw materials processing, which would mean the migration from Australia of the aluminium, iron and steel, and chemical industries.[114]

12.108 Southern Gold supported the examination of domestic use of nuclear power and also noted that if carbon taxes or some regulatory restriction on carbon emissions were imposed on coal fired plants this would make nuclear power more economic in the Australian context.[115]

12.109 As noted in the discussion of greenhouse gas emissions and nuclear power in chapter four, the Uranium Information Centre (UIC) observed that if subsidies and other government incentives are provided to achieve lower carbon emissions, then these incentives:

> … should be applied to anything which achieves low carbon emissions and not … discriminating against nuclear power. In other words, if subsidies are available for wind in Australia, on the basis of carbon reduction, they should be equally available to nuclear.[116]

12.110 Other submitters observed that while nuclear power may not be economically competitive, nevertheless 'the market should be allowed to determine the competitiveness of nuclear generation' in the Australian context.[117]

12.111 It was emphasised that if Australia were to embrace nuclear power, or to develop other fuel cycle services industries, then it would first need to establish a licensing and regulatory framework to support an expanded nuclear industry, which the nation currently lacks.[118] The issue of the domestic skills base to support such developments is considered further below.

12.112 The Committee also notes that the CSIRO is conducting an Energy Futures Forum, as part of the work of the Energy Transformed National Research Flagship Program, which has been set up to bring together a broad range of industry and community groups in a scenario planning exercise exploring potential futures of the Australian stationary energy and

114 *ibid*.

115 Mr Ric Horn, *op. cit*., p. 16.

116 Mr Ian Hore-Lac (UIC), *Transcript of Evidence,* 19 August 2005, p. 90.

117 Mr Andrew Crooks, *Submission no. 84*, p. 8.

118 See: Mr John O Reynolds, *op. cit.*, p. 8. This point is emphasised in ASNO's submission to the Prime Minister's Nuclear Energy Review, *op. cit*., p. 34.

transport industries. Running over an 18-month period, the Forum intends to:

> … develop key energy scenarios that will be modelled by purpose-built world-class techno-economic models to determine potential energy industry and technology pathways and highlight possible impacts to society, environment and the economy. The range of energy scenarios considered will include those addressing the potential for nuclear power in the mix.[119]

12.113 Scenarios will be developed by industry and community forum participants only (assisted by a professional facilitator), and CSIRO and ABARE will provide the modelling tools and analysis.

12.114 In contrast to the support for the establishment, or at least the examination, of a nuclear energy industry in Australia, some 27 submitters to the inquiry expressed opposition to the use of nuclear power in Australia for the reasons addressed at length in chapters five, six, seven and eight (i.e. waste, safety and proliferation).[120]

Defence implications — nuclear propulsion for warships

12.115 The SIA argued that the Australian Government's energy white paper, *Securing Australia's Energy Future*, which was published in June 2004, 'was seriously flawed in not considering nuclear power as a source of energy' in the Australian context.[121] The SIA argued that given the long lead times for the construction of nuclear power plants, 'this makes the priority to revisit this policy all the more urgent.'[122] It was acknowledged that although the domestic use of nuclear power was outside the Committee's terms of reference, the SIA argued that 'your inquiry has sparked serious debate on the matter and I urge you to take any opportunity to cause a review of our policy to occur.'[123]

12.116 The SIA submitted that if Australia were to adopt nuclear power this would then present the nation with an option to consider the acquisition of a nuclear powered submarine capability in the period 2020 to 2050. SIA

119 CSIRO, *Submission no.37*, p. 10.

120 See for example: Mrs Janet Marsh, *Submission no. 2*; MAPW (WA Branch), *Submission no. 8*; The Greens (NT), *Submission no. 9*; Mr John Schindler, *Submission no. 10*; Darwin No War Committee, *Submission no. 13*; The Uniting Church in Australia (Tasmanian and Victorian Synod), *Submission no. 40*; Australian Conservation Foundation, *Submission no. 48*; Public Health Association of Australia, *Submission no. 53*; Mr R Hinkson, *Submission no. 61*; Ms K Winter, *Submission no. 62*; Mr W Lewis, Submission no. 65; Ms J Catalano, *Submission no. 70*; Ms A Macintosh and others, *Submission no. 82*.

121 Rear Adm. Peter Briggs AO CSC (Retired) (SIA), *Transcript of Evidence*, 10 October 2005, p. 28.

122 *ibid*.

123 *ibid*.

argued that trends in the regional security environment make consideration of nuclear propulsion essential as the Collins Class submarine nears the end of its life in 2020–2025.[124]

12.117 Nuclear propulsion in submarines was said to confer several important advantages, including: the capacity to proceed at high speed without endurance constraints and the need to expose the submarine to recharge batteries; and impressive mobility that allows quick response and reduced risk of counter detection.[125]

12.118 It was argued that to operate nuclear powered submarines would almost certainly require a domestic nuclear power industry:

> There is no doubt that nuclear propulsion for submarines offers significant operational advantages in the regional security environment likely to prevail in the medium term—15 to 20 years and beyond. Nevertheless, the introduction of a nuclear powered submarine would be difficult to achieve without commensurate expansion of the nuclear support industry beyond that established for the replacement nuclear research reactor at the Australian Nuclear Science and Technology Organisation. Such an expansion would require a whole-of-government commitment to a nuclear energy program … a nuclear industry base is an essential starting point to create the opportunity to consider such a capability.[126]

12.119 In particular, SIA argued that such a capability would need to be backed up by a 'power generation industry which produces the bulk of graduates and provides the engineering experience that you need in through-life support for the submarine.'[127] It was submitted that without the capability provided by a domestic nuclear power industry, service support and maintenance for the submarines would become extremely expensive and highly dependent on an overseas supplier.[128]

124 SIA, *Submission no. 21*, pp. 8-11.
125 *ibid.*, p. 10.
126 Rear Adm. Peter Briggs AO CSC (Retired), *loc. cit.*
127 *ibid.*, p. 33.
128 SIA, *op. cit.*, p. 11.

The thorium fuel cycle — an alternative for Australia to consider

12.120 Professor Igor Bray, a physicist at Murdoch University and Deputy Director of the ARC Centre of Excellence in Antimatter Studies, argued that, in the Australian context, power derived from the thorium fuel cycle should also be considered. The reasons advanced for this were that: as with uranium, Australia possesses the largest reserves of thorium in the world (as described in chapter three); Australia has not thus far invested to 'go down purely the uranium route'; and thorium promises a number of important potential benefits over the uranium fuel cycle, described below.[129]

12.121 Although the isotope thorium-232 (Th-232) is not itself fissionable, it was explained that, having been initiated with some other fissile material (e.g. U-235 or Pu-239), a breeding cycle similar to but more efficient than that with U-238 and plutonium can be set up. Thorium-232 will readily absorb a neutron to become Th-233 which normally decays to protactinium-233 and then U-233, which is fissile. The irradiated fuel can then be unloaded, separated and then fed back into another reactor as part of a closed fuel cycle.[130] Hence, Th-232 is 'fertile', as is U-238.[131]

12.122 The use of thorium offers potential benefits, including that it produces much less plutonium and other transuranic waste.[132] Thus, the thorium fuel cycle is said to hold non-proliferation and waste advantages over conventional uranium fuel cycles:

> … the thorium fuel cycle has potential for breeding fuel without the need for fast neutron reactors. It is inherently going to be safe. It should lead to considerably less weapons grade material. Waste will be much more manageable, with a shorter half-life. So there is considerable potential. I believe it could be a key factor in the sustainability of nuclear energy.[133]

12.123 In addition, almost all of the mined thorium is potentially usable in a reactor, compared with only 0.7 per cent of natural uranium (the

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129 Professor Igor Bray, *Transcript of Evidence*, 2 March 2006, p 7.

130 Professor Igor Bray, *Exhibit no. 90*, *Thorium based fission,* p. 7.

131 World Nuclear Association (WNA), *Thorium*, Information and Issues Briefs, WNA, London, 2005, viewed 8 May 2006, <http://www.world-nuclear.org/info/inf62.htm>. WNA, *Thorium, loc. cit*.

132 Professor Igor Bray, *Transcript of Evidence*, *op. cit*., p. 3. See also: WNA, *Thorium, loc. cit.* Transuranic elements are very heavy elements formed artificially by neutron capture and possibly subsequent beta decay(s). These elements have a higher atomic number than uranium (92). All are radioactive. Neptunium, plutonium, americium and curium are the best-known.

133 *ibid*., p. 4.

fissionable isotope 235 of uranium): 'So you have about 40 times more energy per unit mass available.'[134]

12.124 It was noted, however, that there are problems associated with use of thorium, including 'a high cost of fuel fabrication, and there are technical problems in reprocessing.'[135]

12.125 The use of thorium based fuel cycles has been studied for some 30 years, but on a far smaller scale than uranium and plutonium. Research has been conducted in Germany, India, Japan, Russia, the UK and the US. While there are several reactor concepts based on thorium fuel cycles under consideration and use of thorium-based fuel is planned for two reactors currently under construction in India, the thorium fuel cycle is yet to be commercialised.[136]

12.126 Friends of the Earth–Australia (FOE) opposed use of Th-232 as a reactor fuel on the grounds that while use of the thorium might reduce proliferation risks, it would not eliminate these risks altogether. For example, FOE stated that the use of HEU or plutonium to initiate a Th-232/U-233 reaction is a proliferation concern and U-233 is a fissile material requiring safeguards protections.[137]

Nuclear skills, training and R&D activity

12.127 A key question which follows proposals to develop domestic value adding industries and possible use of nuclear power is the issue of whether Australia has sufficient skills and expertise to support greater involvement in the nuclear fuel cycle. As noted at the beginning of the chapter, this issue is currently being examined by the Prime Minister's Nuclear Energy Review.

12.128 The CSIRO expressed confidence that Australia does possess the necessary skills to support value adding:

> In short, if Australia wishes to extend its technological operations significantly along the uranium fuel value chain, there are the

134 *ibid*.

135 Professor Igor Bray, *Transcript of Evidence, loc. cit*.

136 *ibid*., p. 3. See for example information on the Energy Amplifier concept, viewed 8 May 2006, <http://press.web.cern.ch/Public/Content/Chapters/AboutCERN/ResearchUseful/Future/Future-en.html>.

137 FOE et. al., *Exhibit no. 71, Nuclear Power: No Solution to Climate Change*, section 3.7.

> necessary research skills within CSIRO and ANSTO to support such developments.[138]

12.129 However, most submitters expressed the contrary view that, in general, Australia lacks the relevant skills and knowledge to support greater involvement in the nuclear fuel cycle. It was also argued that the scope of nuclear research activity undertaken in Australia is now distinctly limited.

12.130 Several submitters argued that most of Australia's expertise relating to nuclear reactors and the fuel cycle, which was developed over several decades by the AAEC, was lost as a result of changes in Government policy in the 1990s and the re-establishment of the Atomic Energy Commission as ANSTO.[139] For example, Mr John Reynolds observed that:

> … Australia does not have as strong a nuclear science and engineering establishment as it did in the early years of the Australian Atomic Energy Commission.[140]

12.131 Likewise, Professor Leslie Kemeny argued that, as the AAEC's successor agency, ANSTO has been:

> … ordered to abandon research and development in most aspects of nuclear power technology and the uranium fuel cycle. Its brief was redirected to the operation of the HIFAR research reactor, environmental research and the production of radioisotopes for hospitals and industry.[141]

12.132 The ANF also submitted that most of the technology and expertise developed by the AAEC throughout the 1960s and 1970s, in conversion, enrichment and fuel fabrication, was subsequently lost:

> … the experience that the AAEC once had in these areas—and we are thinking particularly of nuclear power—has really disappeared with the retirement of people like us. Certainly ANSTO is engaged in various areas of nuclear technology, but there are very few people there these days who understand much about reactors … they are just not allowed to do any further work on that at the present time.[142]

12.133 In terms of the expertise to operate an enrichment industry specifically, Mr Keith Alder argued that while Australia 'had all the know-how to do it

138 CSIRO, *Submission no. 37*, p. 8. See also: Dr Rod Hill (CSIRO), *Transcript of Evidence*, 19 August 2005, p. 2.

139 Mr Keith Alder, *Submission no. 7*, p. 2.

140 Mr John O Reynolds, *Submission no. 5*, p. 8.

141 Professor Leslie Kemeny, *Exhibit no. 9, Power to the people*, p. 1.

142 Dr Philip Moore (ANF), *Transcript of Evidence*, 16 September 2005, p. 47; ANF, *Submission no. 11*, p. 3.

20 years ago', the current situation is markedly different: 'We have lost our own expertise'.[143]

12.134 In terms of the scope of nuclear research undertaken in Australia, Dr Ron Cameron, ANSTO's Chief of Operations, confirmed that under the ANSTO Act the organisation is only permitted to conduct research into nuclear science and technology and it applications, rather than into nuclear energy itself. While the ANSTO Act permits the organisation to 'maintain an understanding of and expertise in the nuclear fuel cycle generally', the organisation has not had an active program in any area of nuclear energy research since it was formed in 1987.[144]

12.135 However, Mr James Brough, President of the ANF, also asked whether Australia has the skills to pursue uranium enrichment:

> Do we have the expertise? Australia ran a successful enrichment project which was cancelled in the early 1980s. The Silex enrichment project, or process, is being developed and it is looking good. So, given time, we could develop the domestic commercial system or we could work with an overseas producer to establish a plant here.[145]

12.136 Professor Ralph Parsons, a former President of AINSE, was also somewhat more optimistic about the potential for Australia's skills:

> Twenty five years ago there was expertise in this country in various stages of the nuclear fuel cycle, particularly in centrifuge enrichment and in the development of Synroc for waste disposal. That expertise has been dissipated but the nation now has sufficient depth of talent in Science, Engineering and Technology that the expertise could be redeveloped if there were the political will to do so.[146]

12.137 CSIRO noted that Australia maintains expertise in reactor operations and radiopharmaceutical manufacture at Lucas Heights, while CSIRO itself conducts research in the area of radionuclide removal from minerals sands and the treatment of rare earth deposits. However, other than CSIRO and ANSTO, it was noted there is now no nuclear science and engineering expertise in any of Australia's universities.

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143 Mr Keith Alder, *Transcript of Evidence*, 16 September 2005, p. 90. Mr Keith Alder, *Submission no. 7*, p. 1.

144 Dr Ron Cameron (ANSTO), *Transcript of Evidence*, 13 October 2005, p. 18. See also: Section 5(1)(a) of the *Australian Nuclear Science and Technology Organisation Act 1987*, viewed 20 April 2006, <http://www.austlii.edu.au/au/legis/cth/consol_act/ansatoa1987505/>.

145 Mr Jim Brough (ANF), *Transcript of Evidence*, 16 September 2005, p. 43.

146 Professor Ralph Parsons, *Submission no. 24*, p. 1.

12.138 It was also argued that if Australia were to value add prior to exporting uranium, technical capabilities would need to be enhanced and coordination of skills would need to be improved:

> Coordination of existing skills around Australia would be necessary to establish a critical mass in support of the industry. At the moment it is quite fragmented. Indeed, no university in Australia has a school of nuclear science and engineering. There would need to be a significant enhancement of those capabilities into the future if we did desire to increase our involvement in the value chain.[147]

12.139 CSIRO argued that key impediments to the establishment of an enrichment industry in Australia are 'the lack of an integrated nuclear science and technology group of researchers in this country' and the role of public perceptions of the acceptability of value adding.[148]

12.140 Professor Kemeny also pointed out that since the closure of the School of Nuclear Engineering at the University of NSW in 1988, Australia has not had a single tertiary level school of nuclear engineering. Nuclear research in Australia is now said to occur solely 'behind the razor wire' of Lucas Heights in Sydney, almost entirely removed from the community:

> … in 1988, the School of Nuclear Engineering at the University of NSW, the only one of its type in Australia was closed after a distinguished 24-year record of operation. In that time it had trained many of the senior staff of the AAEC, the Australian Safeguards Office and the Australian Radiation Protection and Nuclear-Safety Agency. Its Australian and overseas graduates and its staff have produced an impressive list of internationally refereed publications and occupy many important positions in the nuclear energy field around the world. At the same time the Australian School of Nuclear Technology at Lucas Heights, run jointly by the University of NSW and the AAEC, was closed.[149]

12.141 It was argued that Australia's history in nuclear research differs markedly from the situation in the US, where some 30 universities operate their own research reactors, many staffed by trained students.

12.142 Professor Kemeny also expressed the view that public discussion of nuclear-related issues in Australia, such as uranium mining in the Kakadu National Park, the management of radioactive waste, research reactor operations at Lucas Heights and the possible domestic use of nuclear

147 Dr Rod Hill (CSIRO), *Transcript of Evidence*, 19 August 2005, p. 2.

148 *ibid*.

149 Professor Leslie Kemeny, *Exhibit no. 9, Power to the people*, p. 2.

power are 'still largely being debated at the level of talkback radio'. It was argued that 'decision-making in such areas deserves the disciplines of appropriate tertiary education.'[150] Moreover:

> The Australian community has a right to know the relative risks and the environmental impacts of various fuel cycles, as well as the technical limitations, true costs and energy audits of the alternative technologies. Yet Australia is without a single school of nuclear engineering at university level, a situation viewed with incredulity by the academic, diplomatic and political communities of the developing countries of East Asia and the Pacific.
>
> Many of these have a big investment in the growth of peaceful nuclear energy and nuclear science and technology within their borders. For Australia, which is about to displace Canada as the premier uranium exporter, to ignore the study of the uranium fuel cycle and its value-added technologies and industries indicates a pattern of intellectual and economic neglect possibly unparalleled in higher education policy and academic history. Canada has a fully fledged nuclear industry and many schools of nuclear science and engineering.[151]

12.143 Mr Damien Ewington, the Regional Manager Uranium for Areva, confirmed from his own experience that nuclear education is indeed deficient in Australia:

> At least for a generation now the education of young people in this country has, at best, been lacking. At worst, it has been quite negative towards the nuclear industry. I am a geologist by training. The only university education that I had with regard to uranium or the nuclear industry was, quite literally, exposure to what pitchblende or uraninite looks like in year 1 mineralogy class. That was it. Everything I have learned about the nuclear energy industry and uranium exploration in general has been learned on the job since I became a geologist …
>
> You also need to look at nuclear engineers and nuclear physicists and the level of training that goes on in tertiary institutions in Australia. You need to train people … and to educate them in the philosophies of the nuclear energy industry. We could take a step back through to primary and secondary education as well. This is the place where the government could be intimately involved …[152]

150 *ibid*.

151 *ibid*.

152 Mr Damien Ewington (Areva), *Transcript of Evidence*, 23 September 2005, p. 11.

12.144 Professor Kemeny also described the contents of a typical tertiary-level nuclear syllabus and what he contends are some of the potential benefits from improved nuclear education:

> Nuclear engineering … [is] at the leading edge of modern science and technology. Apart from important contributions to the field of energy supply and research, nuclear engineers have made fundamental contributions to society in medicine, agriculture, food technology, metallurgy, industrial control technology and non-destructive testing. They have also contributed to many basic research fields, including fluid flow, heat transfer, material science, neural network theory, radiation health and safety, and artificial intelligence …
>
> Features of the syllabus include every aspect of the uranium fuel cycle from mining to fuel enrichment and fabrication, use in reactors, and reprocessing and waste disposal … The basic principles of Earth's background radiation [and] health and safety issues—so misunderstood by Australian society—are taught in theory and demonstrated by experimental measurement.
>
> At postgraduate level, students learn to design advanced nuclear power plants for electricity generation, desalination, hydrogen production, nuclear marine propulsion, energy systems in space and other industrial application. They can also study radioisotope production for use in medicine, archaeology, agriculture, coastal engineering and non-destructive testing. The design and engineering of fusion systems is also an option.[153]

12.145 The SIA argued that if Australia was to value add or to develop a domestic nuclear power industry, it would need to rebuild its nuclear engineering skills base:

> Australia has lost the capacity it did have, with the nuclear engineering school having closed … There is no doubt that part of the process that would have to be undertaken if you were to contemplate a nuclear power generation industry would be to re-establish the engineering capacity that once was there but which has been, as a matter of policy, closed down.[154]

12.146 SIA noted that the closure of the School of Nuclear Engineering at UNSW has now prompted concerns about a shortage of nuclear engineers and scientists for the next generation:

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153 Professor Leslie Kemeny, *Exhibit no. 43, Pseudo-Science and Lost Opportunities*, pp. 3–4.

154 Rear Adm. Peter Briggs AO CSC (Retired) (SIA), *Transcript of Evidence*, 10 October 2005, p. 32.

> Whilst ANSTO provides a national capability to advise on matters nuclear today, one wonders where the next generation of engineers and scientists will come from?[155]

12.147 It was also argued that it is important for Australia to move beyond the research reactor stage 'to understanding the scale of the kind of engineering that is required in civil reactors in the nuclear power generation business.'[156]

12.148 Similarly, the CSIRO confirmed that the existing skills base in Australia could not be easily coordinated to ensure the optimal development of the uranium industry, and suggested that consideration should be given to

> … the training and development of the next generation of researchers since there is no longer a tertiary institution offering nuclear engineering within Australia and because there is a critical shortage of graduates entering the exploration and mining industry in general.[157]

12.149 However, Professor Igor Bray of Murdoch University argued that, at least in the area of nuclear physics, Australia does have a number of internationally renowned scientists.[158]

12.150 Proposals in evidence to assist in rebuilding Australia's nuclear skills base included:

- re-establishing at least one Australian university school of nuclear engineering;
- broadening ANSTO's R&D mandate, so that it is once again able to undertake physical laboratory studies of aspects of the fuel cycle and nuclear power that may be of benefit to Australia and Australian industry;
- encouraging greater university research into aspects of the nuclear industry and fuel cycle through the research grants awarded by AINSE; and
- actively developing a 'cadre of experts', in a way similar to the original establishment and staffing of the AAEC, including through the use of secondments to countries and companies with operations which Australia may be interested to pursue.[159]

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155 SIA, *Submission no. 21*, p. 5. See also: Mr John O Reynolds, *Submission no. 5*, p. 8.

156 Mr John Thornton (SIA), *Transcript of Evidence*, 10 October 2005, p. 32

157 CSIRO, *Submission no. 37*, p. 12.

158 Professor Igor Bray, *Transcript of Evidence*, 2 March 2006, p. 11.

159 Mr Keith Alder, *Exhibit no. 2, op. cit.*, pp. 16–17.

12.151 Professor Kemeny emphasised the importance of improving tertiary education in nuclear engineering in Australia, and particularly noted its importance for Australia's future:

> In the new millennium there will be increasing use of nuclear science and technology in every field of human endeavour … The global community would be wise to make a significant educational investment in this area and encourage young people to grasp the many professional challenges of a nuclear future.[160]

12.152 Declaring his support for the re-establishment of at least one Australian university school of nuclear engineering, Professor Kemeny argued that:

> The pubic does not relate well to centralised monolithic research laboratories surrounded by barbed-wire. Both fission and fusion physics were born in universities and every effort should now be made to repay this initiative through strong facilities and well equipped laboratories in one or more of Australia's universities.[161]

12.153 As to how such a school might be funded, Professor Kemeny expressed the hope that 'those who benefit from uranium sales might help … start up schools of nuclear engineering'.[162] It was also stated that:

> … Australia's uranium miners should start showing interest in all areas of value-adding technology in the production of commercial grade nuclear fuel and the reprocessing and disposal of nuclear waste.[163]

12.154 Mr Keith Alder argued that one initiative should be an expansion of ANSTO's mandate to conduct laboratory research into aspects of the fuel cycle:

> I would certainly suggest that one of the [initiatives] should be a broadening of the program of ANSTO so that it is involved not only in paper study but also in physical laboratory research, even if it is a long way off, on the treatment of uranium and uranium fuels … I think if you are going to rebuild scientific confidence, you have to put back into the scientific program research and development on the things you want to know about. That is a good start.[164]

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160 Professor Leslie Kemeny, *Exhibit no. 9, op. cit.*, p. 3.

161 Professor Leslie Kemeny, *Exhibit no. 43, loc. cit.*

162 Professor Leslie Kemeny, *Transcript of Evidence*, 16 September 2005, p. 95.

163 Professor Leslie Kemeny, *Exhibit no. 9, loc. cit.*

164 Mr Keith Alder, *Transcript of Evidence*, *op. cit.*, pp. 91–92.

12.155 Mr Alder also argued that AINSE, which consists of representatives of the universities and ANSTO, could also be used to encourage greater research into aspects of the fuel cycle:

> AINSE is a very good body for cooperation between the government research institutions and the universities … When research contracts, research sums and research grants are handed out by AINSE, perhaps they could be slanted more towards the nuclear industry and not just to neutron diffraction and the other things. Then, if you can get university staff interested in and working on matters associated with the nuclear fuel cycle and reactor theory and so on and teaching them, perhaps you are away.[165]

12.156 AINSE provides a focus for cooperation in the nuclear scientific and engineering fields. It has a specific mandate to arrange for the training of scientific research workers and the award of scientific research studentships in matters associated with nuclear science and engineering. AINSE explained that it provides competitive funding by which university researchers and research students gain access to the facilities and expertise at ANSTO. AINSE awards some 200 nuclear-related research grants each year under a National Competitive Research Grants Scheme, and supports over 100 PhD students who are working on projects requiring access to nuclear science facilities.[166]

12.157 AINSE itself submitted that it could play a role as a facilitator for university-based strategic research on the nuclear fuel cycle, particularly in the following areas: (i) underlying nuclear and materials science though national and international collaboration; (ii) the beneficiation of nuclear waste through accelerator-driven transmutation treatment; and (iii) nuclear fusion research, which is discussed further below.[167]

12.158 In terms of the nuclear skills base in Australia, Dr Ian Smith, Executive Director of ANSTO, stated that there is currently a worldwide shortage of people with skill sets for the nuclear industry. This situation was said to exacerbate the Australian problem, 'because we do not have an indigenous source of people coming out with training.'[168] ANSTO explained that it has responded to this situation by instituting its own

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165 *ibid.*, p. 92.

166 AINSE, *op. cit.*, p. 1. See also: AINSE, *About AINSE*, viewed 20 October 2006, <http://www.ainse.edu.au/ainse2.html>.

167 *ibid.*

168 Dr Ian Smith (ANSTO), *Transcript of Evidence*, 13 October 2005, p. 18.

training program and sending its graduate recruits to international destinations.[169]

12.159 Dr Smith observed that while ANSTO does currently interact with universities and the construction of the replacement reactor has refreshed skills and allowed some technology transfer, 'to maintain that I think it would be sensible to have a program with some universities and an overseas company or university to work with.'[170]

12.160 The Committee regrets that Australia has lost the expertise it once held in nuclear energy and the fuel cycle. The Committee notes with concern that, since 1988, Australia has not had a tertiary-level school of nuclear engineering. Consequently, Australia has no indigenous source of trained personnel in the nuclear field. It is also a concern that successive Australian Governments have prohibited ANSTO from conducting any nuclear energy and fuel cycle R&D.

12.161 In order to facilitate the possible eventual development of fuel cycle services industries in Australia and to allow for the possible eventual use of nuclear energy, as well as to provide appropriately qualified staff for Australian regulatory agencies, the Committee concludes that the Australian Government should seek to progressively rebuild Australia's nuclear skills base. The Committee is concerned that Australia is already experiencing a shortage of suitably qualified people with skill sets for the nuclear and associated industries. This is a matter that merits Government attention, regardless of whether Australia expands its involvement in the nuclear fuel cycle.

12.162 Among its other proposals, the Committee recommends that the Government examine re-establishing a University School of Nuclear Engineering and an Australian Research Council Research Network or Centre(s) of Excellence in the relevant fields. One of the benefits of this approach would be to take the study of the nuclear fuel cycle out from 'behind the fence' of Lucas Heights, thereby encouraging greater public understanding, awareness and acceptance of this important field of study and research.

12.163 The Committee supports broadening ANSTO's R&D mandate to undertake studies of the fuel cycle and nuclear energy. The Committee is enthused at the possibilities presented by the new Open Pool Australian Light-water (OPAL) reactor as a platform for attracting graduate students interested in the opportunities that R&D of this kind may present. The Committee also calls upon the private sector, notably the uranium

169 *ibid.*, p. 19.

170 *ibid.*

industry, to support such developments, for example by funding relevant university scholarships and working more closely with ANSTO.

12.164 The Committee further recommends that Australian nuclear scientists and engineers be assisted to study at overseas universities and with companies where relevant skills could be obtained. A program of secondments should also be developed with technical departments of the IAEA for suitably qualified Australian nuclear scientists and engineers.

Recommendation 13

The Committee recommends that the Australian Government take steps to rebuild Australia's nuclear skills base and expertise by:

- **broadening the Australian Nuclear Science and Technology Organisation's (ANSTO) research and development mandate, so that it is able to undertake physical laboratory studies of aspects of the nuclear fuel cycle and nuclear energy that may be of future benefit to Australia and Australian industry;**
- **developing a program whereby Australian nuclear scientists and engineers are assisted to study at overseas universities and/or to be placed with companies where relevant expertise resides, in order to expand Australia's knowledge base;**
- **increasing engagement by Australian nuclear scientists and engineers at a technical level with the International Atomic Energy Agency, for example through a program of secondments and placements;**
- **examining the possibility of re-establishing at least one Australian University School of Nuclear Engineering and an Australian Research Council Research Network or Centre(s) of Excellence in the relevant fields;**
- **encouraging industry to increase its collaborations with and support of ANSTO's proposed expanded research activities and any school of nuclear engineering that may be established; and**
- **encouraging greater university research into aspects of nuclear energy and the nuclear fuel cycle through the allocation of research grants awarded by the Australian Institute of Nuclear Science and Engineering.**

Fusion energy research

12.165 The Committee was informed of the potential merits of fusion power and the status of technological development for this energy source by representatives of the Australian International Thermonuclear Experimental Reactor (ITER) Forum (the Forum). The Forum comprises over one hundred Australian scientists and engineers engaged in aspects of fusion energy science, with the scientists drawn from five Australian universities and ANSTO. The goal of the Forum is controlled fusion as an energy source.[171]

12.166 Whereas power from nuclear reactors is generated by the process of fission, which is the splitting of a heavy atomic nucleus (uranium-235) with a consequent release of energy, fusion is the combination of two light nuclei to form more massive nuclei with the consequent release of energy. In essence, the fusion process is the opposite to fission.[172] Fusion occurs continuously in the universe. In the core of the sun, at temperatures of 10–15 million degrees celsius (°C), hydrogen is converted to helium, providing the energy that sustains life on earth.

12.167 The most straightforward fusion reaction to initiate is the combination of two isotopes of hydrogen (deuterium and tritium) to form helium and a neutron, releasing energy in the process. Along with fission, the energy output of fusion is 'millions of times greater than that of coal', as indicated in table 12.5.[173] In theory, a fusion reaction involving ten grams of deuterium (which can be extracted from 500 litres of water) and 15 grams of tritium (produced from 30 grams of lithium), would produce enough energy to supply the lifetime electricity needs of an average person in an industrialised country.[174]

12.168 In the sun, gravity is sufficiently strong to overcome the repulsive force between the similarly charged atoms. On earth, gravity is too weak and the material must be heated to over 100 million °C. In order to constrain the material at such high temperatures strong magnetic fields are used, with the most advanced being the 'tokamak', a doughnut-shaped vessel in which the plasma resides.

171 Dr Matthew Hole (Australian ITER Forum), *Transcript of Evidence*, 8 December 2005, p. 1.

172 *ibid.*, pp. 1–2.

173 *ibid.*, p. 2.

174 M Hole and J Howard, *Australia cannot afford to miss the fusion train*, Canberra Times, 29 June 2005, p. 17.

Table 12.5 Comparison of energy release per reaction

Fission ($U^{235} + n \rightarrow Xe^{134} + Sr^{100} + n$)	200 000 000 units*
Fusion ($D^2 + T^3 \rightarrow He^4 + n$)	17 600 000 units
Coal ($C_6H_2 + 6.5\ O_2 \rightarrow 6\ CO_2 + H_2O$)	30 units

Source Australian ITER Forum, *Exhibit no. 83, Presentation by Dr Matthew Hole*, p. 3.
* Units are electron volts per reaction

12.169 The possibility of producing energy for commercial use by fusion has been researched for several decades. A growing consortium of countries (with seven full partners to date including China, Korea, EU, Japan, Russia, India and the US) are cooperating to construct the next-generation fusion test reactor—the International Thermonuclear Experimental Reactor (ITER, which also means 'the way' in Latin)—under the auspices of the IAEA. In June 2005 it was announced that the reactor will be built at Cadarache in southern France, for an estimated A$10 billion. The ten-year operation costs will amount to an additional $6 billion.

12.170 The Forum noted that, aside from the international space station, ITER is world's largest science project and fusion R&D is ranked as the highest funding priority by the US Department of Energy.[175]

12.171 The ITER will be a 500 megawatt experimental reactor (equivalent in size to a medium-sized coal-fired plant) with three principal objectives: to demonstrate fusion energy for peaceful purposes ('ITER is a pre-prototype power plant and the last large-scale fusion energy experiment en route to power production'); to explore the 'burning plasma regime'; and to demonstrate the integration of technologies and address materials issues.[176] It is intended that following the ITER experiment, a demonstration reactor will be constructed in 2025, enabling the construction of the first commercial fusion power plant by around 2050.

12.172 It was claimed that if commercial fusion reactors become practicable, they will offer a number of important advantages, particularly in comparison to fission technology:

- fusion is inherently safe as there can be no chain reactions, explosions or meltdowns;
- fusion will be unable to produce fissile materials that can be used for weapons;

175 Dr Matthew Hole, *op. cit.*, p. 3.
176 *ibid.*

- there is a virtually unlimited supply of fuel:

> Even using the most extravagant world energy use predictions, there is sufficient D-T [deuterium-tritium] to power the earth for tens of thousands of years. This is beyond civilisation time scales. Using a next generation fusion reaction—a deuterium-deuterium reaction—there is sufficient fuel to power the earth for millions of years.[177]

- fusion produces only small amounts of radioactive waste and almost all is short lived:

> Even employing present-day ferritic technology in the vessel structure, a fusion power plant is 3,000 times less radioactive than its fission equivalent 100 years after shutdown. Indeed, within one human lifetime the entire fusion power plant could be completely recycled. Using future vanadium alloy structures, fusion is a staggering one million times less radioactive after 30 years than fission.[178]

12.173 In terms of the costs of generating electricity, the Forum argued that the internal costs of fusion, which includes construction, fuelling, operating the plant and decommissioning, are comparable to those of fission (and less costly than gas). As to the external costs, which include estimates of environmental damage and impacts on public and worker health, fusion is very attractive and was said to be comparable to wind.[179]

12.174 Other evidence also suggested that fusion has good prospects for making an economically attractive contribution to the future energy mix. Initially, the internal costs of fusion electricity would be some 50 per cent more expensive than electricity from fossil fuels and roughly comparable to renewables. The use of advanced materials will lead to an internal cost of fusion electricity approaching that of fission or fossils fuels. Fusion has small external costs and is about an order of magnitude lower than fossil fuel electricity.[180]

12.175 The Committee was informed that Australia has a history of fusion energy research and it was claimed that an Australian, Sir Mark Oliphant, actually discovered the fusion process in 1934. In 1946 a graduate of the University of Sydney, Dr Peter Thonemann, pioneered early fusion research in the UK and in 1958 Sir Mark Oliphant commenced plasma

177 *ibid.*, p. 2.
178 *ibid.*
179 *ibid.*, pp. 10–11.
180 Australian ITER Forum, *Exhibit no. 85, Prospects for economic fusion electricity*, p. 25.

physics research at the ANU. It was argued that Australian fusion research continues to make valuable contributions.[181]

12.176 The Australian ITER Forum argued that a range of potential benefits and opportunities would follow if Australia were to increase its engagement in ITER and fusion energy research. These include:

- an abundant supply of future base-load energy to replace fossil fuels;
- combined with the translation to electric transportation, fusion offers Australia and the world energy independence from oil and an end to the geopolitical instability brought by the regional concentrations of oil—that is, energy security;
- near-term economic and political benefits, with some 80 per cent of the A$10 billion construction cost of ITER returned to industry through contracts;
- science and technology benefits, which will also impact on other forms of energy production and industries, such as aerospace;
- training and retention of skills;
- responding to climate change;
- fostering international research links;
- scientific credibility; and
- enhance Australia's position in the IAEA.[182]

12.177 In summary, it was argued that fusion energy 'offers the world a near zero greenhouse gas emission base-load power supply, capable of sustaining civilisation for millions, if not billions of years.'[183] It was argued that a low CO_2 emission strategy requires investment in a range of nuclear and renewable technologies, and that fusion offers clear benefits:

> Fusion provides not only an endless source of energy for our civilisation but an endless range of opportunities for Australian science and industry, if we embrace its opportunities early enough to remain competitive. The ITER project offers a path forward to access these opportunities. The window of opportunity to maximise Australia's competitive advantage is, however, closing as I speak. For this reason alone, involvement in the ITER project needs to be urgently addressed by the Commonwealth.[184]

181 Australian ITER Forum, *Exhibit no. 83, Presentation by Dr Matthew Hole*, p. 12.
182 *ibid.*, p. 13.
183 Dr Matthew Hole, *op. cit.*, p. 1.
184 *ibid.*, p. 5.

12.178 The Forum argued that, perhaps most importantly, Australia possesses many of the advanced materials which will be in demand for the construction of fusion reactors, such as vanadium, tantalum, titanium, zirconium and niobium. Australia's share of these resources is listed in table 12.6. Australia also has some four per cent of the world's lithium, which is used to produce tritium for fusion reactions. One mine in Western Australia currently produces 60 per cent of the world's lithium minerals in concentrate form.[185] The Forum argued that this represents an opportunity for Australia to value add by processing and manufacturing the elements required, rather than sell them in their raw state.

Table 12.6 Australia's share of fusion related materials

Aspect of fusion process / reactor	Mineral	Australian EDR[3] in kilotonnes (% of world)	Australian total[1] in kilotonnes
Fuel	Lithium	170 (4.1%)	257
Structural	Vanadium	2 586 (19.9%)	5 061
	Tantalum	53 (94.6%)	154.2
	Titanium[2]	80.7 (21.5%)	158.7
	Zirconium[2]	14.9 (40.5%)	40.9
Superconductor	Niobium	194 (4.3%)	2 147

Source Australian ITER Forum, *Exhibit no. 83, Presentation by Dr Matthew Hole*, p. 17.
[1] Demonstrated plus inferred resources
[2] Inferred from mineral sand deposits
[3] Economic Demonstrated Resources

12.179 Professor Kemeny also expressed support for further fusion energy research, noting that fusion 'offers the prospect of an almost inexhaustible supply of energy for future generations'.[186]

12.180 AINSE submitted that it has maintained an interest in fusion research and that greater participation in this experimentation will have a number of benefits, including the opportunity for Australia to develop and share in intellectual property which will, in the future, be of considerable value. It was also argued that ITER presents an opportunity for Australian industry to participate in materials research and eventually the production of the specialised materials required for the containment of the plasma. Australian expertise could also be involved in the design and development of software needed to control the fusion reaction.[187]

185 This is the Greenbushes mine, owned by Sons of Gwalia Ltd, *Greenbushes Mine Fact Sheet*, viewed 4 May 2006, <http://www.sog.com.au/pages/amd_greenbushes.asp>. Dr Matthew Hole (Australian ITER Forum), *Transcript of Evidence*, 8 December 2005, p. 8.

186 Professor Leslie Kemeny, *Exhibit no. 42, Emerging Nuclear Energy Systems – A One Hundred Year Perspective*, p.6.

187 AINSE, *op. cit.*, p. 2.

12.181 In other evidence, Professor Igor Bray commented that Australian scientists will be consultants to ITER and provide data for aspects of the project.[188]

12.182 The Australian ITER Forum argued that in order to preserve and grow Australia's fusion research program it was necessary that fusion science become a national research priority. It was also recommended that:

- Australia should negotiate a subscription to ITER as a matter of urgency, as the 'window of opportunity is quickly closing'; and
- a national or international research centre be established to consolidate Australia's efforts in fusion related research.[189]

12.183 While the cost of being a full partner in the ITER project is 10 per cent of the total, the Australian ITER Forum stressed that engagement is possible with subscriptions of a significantly lower fraction than this, perhaps even less than one per cent. Countries can also make contributions in kind by offering materials. However, the Forum stated that this would require engagement by the Australian Government with the ITER negotiators:

> We certainly could, but that would require negotiation between government and the ITER negotiators. It is something we would like to bring to the attention of government, but we feel that that level of interaction really needs to come clearly from government.[190]

12.184 It was argued that if Australia were to subscribe to ITER, 'that money would flow back to Australia. So the demand would be there for the lithium or titanium or whatever they want and that money would come back'.[191]

12.185 A complexity in achieving Government engagement was argued to be the diverse nature of fusion research. Fusion research does not fall under any one portfolio, with elements of the research come under some four government portfolios.

12.186 In relation to a domestic research centre, the Forum argued that 'Australian graduates are highly sought after by the world's large fusion laboratories' and therefore a domestic fusion research centre was essential to 'to preserve and grow existing competence.'[192]

188 Professor Igor Bray, *Transcript of Evidence*, *op. cit.*, pp. 2, 6.
189 Dr Matthew Hole, *op. cit.*, pp. 3, 5.
190 *ibid.*, p. 8.
191 Professor John O'Connor (Australian ITER Forum), *Transcript of Evidence*, 8 December 2005, p. 8.
192 Dr Matthew Hole, *op. cit.*, p. 4.

12.187 Subsequent to their attendance at a public hearing, the Australian ITER Forum advised the Committee that in December 2005 the Australian Government agreed to fund the visit to Australia of ITER partners to discuss the project with Australian Government officials.

12.188 FOE argued that fusion poses a number of weapons proliferation risks, including: the production or supply of tritium, which can be diverted for use in boosted nuclear weapons; and plasma physics research can be used as a cover for development of nuclear weapons technologies.[193]

12.189 The Committee is persuaded of the immense potential benefit that fusion energy represents for the world and, specifically, the potential benefits for Australian science and industry from involvement in the ITER project. The Committee believes that involvement in this experimentation is simply too important for the nation to miss, even if the introduction of fusion power is indeed many decades off. Accordingly, the Committee recommends that Australia secure formal involvement in the ITER project and seek to better coordinate its research for fusion energy across the various fields and disciplines in Australia.

Recommendation 14

The Committee recommends that the Australian Government:

- **negotiate an appropriate subscription for Australia to the International Thermonuclear Experimental Reactor project on a whole-of-Government basis;**
- **support the establishment of a national research centre to consolidate and coordinate Australia's efforts in fusion related research; and**
- **examine the merits of establishing fusion science as a national research priority.**

Conclusions

12.190 The Committee agrees that for Australia to possess such a large proportion of the world's uranium resources—approximately 40 per cent of the global total—and *not* to have taken up opportunities over the past 35 years to develop uranium enhancement industries is highly regrettable. In addition to the foregone export earnings and the missed opportunities

193 FOE et. al, *loc. cit*.

to develop sophisticated technologies and an associated domestic knowledge base, the failure to press ahead with the development of fuel cycle services industries in Australia has wasted a significant public R&D investment. This had amounted to some $100 million by the time of the termination of the AAEC's enrichment research in the mid 1980s. The nation has also lost a generation of nuclear research and engineering expertise.

12.191 In addition to domestic economic and technological benefits, increased involvement by Australia in the fuel cycle could have non-proliferation and security advantages. Indeed, as argued by some submitters, fuel cycle facilities could well be established in Australia on a multination basis, in accordance with the IAEA's expert advisory group recommendations outlined in chapter seven, thereby providing a high level of transparency for regional neighbours and the international community generally. Such a development would have clear global non-proliferation benefits, while also allowing Australia the opportunity to extract greater returns from its immense uranium resource endowment, to develop sophisticated technologies and to expand its national skills base.

12.192 The Committee urges that state governments re-evaluate the merits of the eventual establishment of such industries within their jurisdictions, particularly in the uranium rich jurisdictions of South Australia, the Northern Territory and Western Australia. Furthermore, the Committee wishes to encourage Australian companies, such as those that participated in the UEGA enrichment industry proposals of the early 1980s, to actively consider the opportunities such developments might present in the future.

12.193 Although the Committee is naturally pleased that Silex has succeeded in partnering with GE to develop its laser enrichment technology in the important nuclear fuel market of North America, again the Committee regrets that this technology could not be commercialised in Australia. The Committee notes the significant returns that could be earned from the establishment of an Australian enrichment industry using SILEX technology.

12.194 The Committee concludes that, by virtue of its highly suitable geology and political stability, Australia could also play an important role at the back-end of the fuel cycle in waste storage and disposal. Again, such a development could be highly profitable, as well as possibly providing global security benefits. However, as noted in chapter five, the US GNEP initiative proposes to revolutionise spent fuel management (through the use of advanced burner reactors in the 'fuel supplier' nations), generating waste requiring short isolation periods. This could obviate the need for geologic repositories altogether. However, even if Australia were to receive back the waste generated from use of Australian-sourced uranium alone, this could still generate annual revenues in the billions of dollars, as well as developing highly sophisticated technologies. The Committee also notes that the IAEA has suggested the eventual establishment of back-end facilities on a multinational basis. Given the prospect that some nations currently using nuclear power will not be able to establish domestic repositories (e.g. due to unsuitable geology), this is a service that Australia could be uniquely positioned to provide for the world.

12.195 The Committee has no in-principle objection to the use of nuclear power in Australia and believes that, subject to appropriate regulatory oversight, utilities that choose to construct nuclear power plants in Australia should be permitted to do so. There would be clear greenhouse gas emission and other technological and potential economic benefits from doing so.

12.196 Nuclear power may not be immediately competitive in the Australian context, due to the quantity and quality of Australia's coal resources (and that carbon emissions are currently not priced). However, the Committee believes that if Federal and state governments continue to provide a range of incentives to achieve low carbon emissions, for example by subsidising renewables such as wind, then governments should not discriminate against nuclear power—which will also achieve very low emissions and generate base load power, unlike the currently subsidised renewable alternatives.

12.197 Even if the domestic use of nuclear energy and uranium enhancement industries in Australia are not established in the near future, the Committee recommends that the Australian and state governments commence examining best practice licensing and regulatory frameworks that could be put in place to facilitate the eventual establishment of such facilities.

12.198 Should the nation ever wish to develop uranium enhancement industries or to use nuclear energy, it seems likely that the relevant skills base would need to be rebuilt (a possible exception being nuclear waste treatment, given ANSTO's Synroc technology and expertise).

12.199 The Committee notes that Australia no longer has a domestic source for the training of nuclear scientists and engineers. Relevant training is undertaken 'in house' by ANSTO and its personnel are sent to overseas destinations. While the Committee is pleased that this occurs, it believes that the Australian Government should now take steps to rebuild Australia's nuclear expertise and skills base. Initiatives the Committee recommends include examining the re-establishment of a university school of nuclear engineering. The Committee calls upon the uranium industry to support such developments, for example by funding relevant university scholarships. The Committee also proposes that ANSTO's research mandate once again be broadened to undertake actual R&D into aspects of the fuel cycle and the use of nuclear energy.

Supplementary remarks

12.200 The three Labor members of the Committee offer qualified support for the recommendations and conclusions of Chapter 12 as follows:

- The Labor members of the Committee note that whilst there is conflicting evidence about the demand for new enrichment facilities, the lack of governance for enrichment facilities under the NPT and IAEA safeguards regime should preclude the development of new enrichment facilities anywhere in the world. Under the current regime, there is nothing illegal about any country having enrichment technology. Yet the acquisition of highly-enriched uranium or separated plutonium is one of the most technically difficult but important steps towards making a nuclear weapon. If a country with a full nuclear fuel cycle decided to break away from its non-proliferation commitments, a nuclear weapon capability could be within reach in a short time. This is the dilemma now confronted in Iran. As the UN struggles to hold it to account under the NPT and the IAEA safeguards regime, it has never been clearer that the NPT should be reviewed to address the ambiguity about the alleged right of nations to acquire proliferation-sensitive technologies, such as enrichment facilities. The Committee urged that the NPT be reviewed to address this question in chapter seven. The Labor members support such a review and Dr Mohamed ElBaradei's (Director General of the IAEA) May 2005 proposal for a five-year moratorium on the establishment of new enrichment and reprocessing facilities to allow such a review to be completed. The Labor members further note that Australia lacks the skills-base necessary to support a domestic enrichment industry. The Labor members are therefore opposed to an enrichment industry in Australia.
- The Labor members of the Committee note that, whilst there is considerable evidence that Australia's geology is highly suitable for the disposal of nuclear waste and that, theoretically, Australia has the technological and skills capacity to develop a nuclear waste industry, the reality is that Australia has not yet been able to leverage this capacity to manage its own low and intermediate level waste. The Labor members are of the view that this is related to a history of

dishonest political campaigns and a failure of national leadership on this issue. Without first developing and proving Australia's capacity to manage domestic low and intermediate level waste, Labor members believe it would be imprudent to consider any further development of a nuclear waste industry in Australia. The Labor members also note that Australia's technology and skills capacity is being exported to manage nuclear waste in other countries, providing a value-adding opportunity to Australian entities. Further, Labor members note that, according to the Australian Strategic Policy Institute in its August report on uranium exports and security, provided nuclear waste facilities are subject to the IAEA safeguards regime wherever they are located in the world, there is no security imperative to import nuclear waste to Australia for management. The Labor members are therefore opposed to the importation of nuclear waste to Australia.

- The Labor members of the Committee note that the overwhelming evidence is that, now and for the foreseeable future, nuclear power in Australia is not economic and Australia lacks the skills-base necessary to support a domestic nuclear power industry. The Labor members are of the view that Australia has two current options for securing reliable, competitive baseload power in the long term—clean coal and nuclear. The Labor members believe that Australia's low electricity prices as a result of coal-fired power generation are a key source of competitive advantage for the nation's industries and Australia's priority should therefore be to clean up coal-fired power generation, increase the uptake of gas and renewable technologies for peaking and niche markets, and support the research and development of renewable technologies for future baseload. The Labor members are therefore opposed to a nuclear power industry in Australia.

The Hon Geoff Prosser MP

Chairman

November 2006

A

Appendix A — List of submissions

Number	From
1	Mr Robert Elliott
2	Ms Janet Marsh
3	Australian Academy of Technological Sciences and Engineering (AATSE)
4	Wind Prospect Pty Ltd
5	Mr John Reynolds
6	Compass Resources Ltd
7	Mr Keith Alder
8	Western Australian Branch of the Medical Association for Prevention of War (MAPW)
9	The Greens (Northern Territory)
10	Mr John Schindler
11	Australian Nuclear Forum Inc (ANF)
12	Uranium Information Centre (UIC)
12.1	Uranium Information Centre (UIC) (*Supplementary to Submission No. 12*)
13	Darwin No War Committee
14	Australian Bureau of Agriculture and Resource Economics (ABARE)
15	Summit Resources Ltd
16	Deep Yellow Ltd
17	Australian ITER Forum

17.1	Australian ITER Forum (*Supplementary to Submission No. 17*)
18	Eaglefield Holdings Pty Ltd
19	Australian Nuclear Association (ANA)
20	Association of Mining and Exploration Companies (AMEC)
21	Submarine Institute of Australia (SIA)
22	Arafura Resources NL
23	Mr Nick Pastalatzis
24	Professor Ralph Parsons
25	Anonymous
26	CFMEU Mining & Energy
27	Dr Gavin Mudd
28	The Environment Centre NT Inc (ECNT)
29	Australian Nuclear Science and Technology Organisation (ANSTO)
29.1	Australian Nuclear Science and Technology Organisation (ANSTO) (*Supplementary to Submission No. 29*)
30	Victorian Branch of the Medical Association for Prevention of War (MAPW)
30.1	Victorian Branch of the Medical Association for Prevention of War (MAPW)
31	Jindalee Resources Ltd
32	Australian Radiation Protection and Nuclear Safety Agency (ARPANSA)
32.1	Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) (*Supplementary to Submission No. 32*)
33	Hon Alexander Downer MP
33.1	Hon Alexander Downer MP (*Supplementary to Submission No. 33*)
33.2	Hon Alexander Downer MP (*Supplementary to Submission No. 33*)
33.3	Hon Alexander Downer MP (*Supplementary to Submission No. 33*)
33.4	Hon Alexander Downer MP (*Supplementary to Submission No. 33*)
34	Professor Peter Parsons

35	Mr Alan Parker
36	Minerals Council of Australia (MCA)
37	Commonwealth Scientific Industrial Research Organisation (CSIRO)
37.1	Commonwealth Scientific Industrial Research Organsiation (CSIRO)
	(*Supplementary to Submission No. 37*)
38	APChem Scientific Consultants
39	Areva Group
40	The Uniting Church in Australia (Synod of Victoria and Tasmania)
41	Mr Justin Tutty
42	Geoscience Australia (GA)
43	Cameco Corporation
44	Gundjeihmi Aboriginal Corporation
45	People for Nuclear Disarmament NSW Inc
46	Energy Resources of Australia Ltd (ERA)
47	Paladin Resources Ltd
48	Australian Conservation Foundation (ACF)
49	Heathgate Resources Pty Ltd
50	Nova Energy Ltd
51	Northern Territory Minerals Council Inc (NTMC)
52	Friends of the Earth - Australia (FOE)
52.1	Friends of the Earth - Australia (FOE)
	(*Supplementary to Submission No. 52*)
52.2	Friends of the Earth - Australia
	(*Supplementary to Submission No. 52*)
52.3	Friends of the Earth - Australia
	(*Supplementary to Submission No. 52*)
52.4	Friends of the Earth - Australia
	(*Supplementary to Submission No. 52*)
53	Public Health Association (PHA)
54	Southern Gold Ltd
54.1	Southern Gold Ltd
	(*Supplementary to Submission No. 54*)
55	Department of Environment and Heritage (DEH)

55.1	Department of Environment and Heritage (DEH) (*Supplementary to Submission No. 55*)
55.2	Department of Environment and Heritage (DEH) (*Supplementary to Submission No. 55*)
56	Ms Pepita Maiden
57	Mr Brett Hedger
58	Dr Manuel Needleman
59	Mr David Addison
60	AMP Capital Investors Sustainable Funds Team
61	Mr Richard Hinkson
62	Ms Kathleen Winter
63	Ms Jeanie Wylie
64	Professor Leslie Kemeny
65	Mr W Lewis
66	BK Daly-King
67	Mr Colin Mitchell
68	Mr Barry Morgan
69	Ms Corinne Salmon
70	Ms Jennifer Catalano
71	Mr Lance Joseph
72	Professor Richard Broinowski
73	Ms Jo Vallentine
74	Mrs Judy Forsyth
75	Arid Lands Environment Centre Inc (ALEC)
76	Ms Ilona Renwick
76.1	Ms Ilona Renwick (*Supplementary to Submission No. 76*)
77	Australian Institute of Nuclear Science and Engineering (AINSE)
78	Northern Land Council (NLC)
78.1	Northern Land Council (NLC) (*Supplementary to Submission No. 78*)
79	Alice Action Executive Committee (AAEC)
	These same points were also made in correspondence received from the following individuals:
	Ms Julia Hengstler

	Ms Adelaide Church
80	Ms Stephanie Riddel
81	Ms Caroline Pembroke
82	Ms Annetta MacIntosh
	These same points were also made in correspondence received from the following individuals:
	Ms Julie Bennett
	Mr Grant Cawsey
	Ms Ann Roberts
	Mr John Roberts
	Mr Alan Scott
83	Ms Rita Warleigh
	These same points were also made in correspondence received from the following individuals:
	S Hollamby
	Ms Ainslie Langdon
	Ms Irene Leben
	Ms Norma Nable
	Mr Lewis O'Keefe
	M Ticehurst
	Mr Louis Warwick
84	Mr Andrew Crooks
85	Mr Daniel Taylor
86	Mr John Klepetko
87	Mr Robert Gishubl

B

Appendix B — List of exhibits

Number	From
1	Emission Traders International (ETI) - Correspondence
2	Mr Keith Alder *Australia's Uranium Opportunities* (related to Submission No. 7)
3	Mr Donald Perkin *The Significance of Uranium Deposits Through Time* - thesis by Mr Donald Perkin, May 1996
4	Australian Nuclear Forum Inc (ANF) *Australian Uranium Enhancement Industries* - policy document of the Australian Nuclear Forum Inc (related to Submission No. 11)
5	Australian Nuclear Forum Inc (ANF) *Uranium Mining in Australia* - policy document of the Australian Nuclear Forum Inc (related to Submission No. 11)

6	L and M Kemeny Consulting *A Review of the Global Environmental Impact of Fossil & Nuclear Fuels* - paper by Prof Leslie Kemeny
7	L and M Kemeny Consulting *Nuclear Energy and the Greenhouse Problem* - paper by Prof Leslie Kemeny
8	L and M Kemeny Consulting *A power too good to refuse* - article by Prof Leslie Kemeny
9	L and M Kemeny Consulting *Power to the people* - article by Prof Leslie Kemeny
10	L and M Kemeny Consulting *Going Nuclear: it's the new green* - article by Prof Leslie Kemeny
11	Construction, Forestry, Mining and Energy Union (CFMEU) *CFMEU Submission to the Senate Environment, Communications, Information Technology and the Arts Reference Committee's Inquiry into Environmental Regulation of Uranium Mining* (related to Submission No. 26)
12	Dr Gavin Mudd *Compilation of Uranium Production History and Uranium Deposit Data Across Australia* - paper by Dr Gavin Mudd (related to Submission No. 27)
13	Dr Gavin Mudd *Mound springs of the Great Artesian Basin in South Australia: a case study from Olympic Dam* - paper by Dr Gavin Mudd (related to Submission No. 27)

14	Dr Gavin Mudd *Uranium Mill Tailings Wastes in Australia: Past, Present & Future Management - Research Report Summary* - paper by Dr Gavin Mudd (related to Submission No. 27)
15	Dr Gavin Mudd *Remediation of Uranium Mill Tailings Wastes in Australia: A Critical Review* - paper by Dr Gavin Mudd (related to Submission No. 27)
16	Dr Gavin Mudd *Critical review of acid in situ leach uranium mining: 1. USA & Australia* - paper by Dr Gavin Mudd (related to Submission No. 27)
17	Dr Gavin Mudd *Critical review of acid in situ leach uranium mining: 2. Soviet Block & Asia* - article by Dr Gavin Mudd (related to Submission No. 27)
18	Dr Gavin Mudd *Uranium mining in Australia: Environmental impact, radiation releases & rehabilitation* - paper by Dr Gavin Mudd (related to Submission No. 27)
19	Dr Gavin Mudd *Environmental hydrogeology of in situ leach uranium mining in Australia* - paper by Dr Gavin Mudd (related to Submission No. 27)
20	Dr Gavin Mudd *Uranium Mining and Hydrogeology III* - paper by Dr Gavin Mudd (related to Submission No. 27)

21 Dr Gavin Mudd
A Compendium of Radon Data for the Rehabilitation of Australian Uranium Projects
- paper by Dr Gavin Mudd
(related to Submission No. 27)

22 Dr Gavin Mudd
*One Australian Perspective on Sustainable Mining : Declining Ore Grades & Increasing Wast Volume*s
- paper by Dr Gavin Mudd
(related to Submission No. 27)

23 Prof Peter Parsons
Radiation Phobia and Phantom Risks
- paper by Prof Peter Parsons
(related to Submission No. 34)

24 Dr Helen Caldicott
Nuclear power is the problem, not a solution
- article by Dr Helen Caldicott

25 Dr Helen Caldicott
Nuclear Madness - What you can do (Revised Edition)
- publication by Helen Caldicott

26 L and M Kemeny Consulting
A cheap and effective solution to an energy and water-hungry future
- article, The Canberra Times, 4 November 2003

27 L and M Kemeny Consulting
50 Years of Nuclear Science and Engineering in Australia
- article, Energy News, September 2003

28 L and M Kemeny Consulting
Renewable energy debate makes little sense
- article, The Lithgow Mercury, 21 October 2003

29	L and M Kemeny Consulting *A new solution needed for Australia's water and energy problem* - article by Prof Leslie Kemeny
30	L and M Kemeny Consulting *Global trends in nuclear education at the tertiary level* - paper by Prof Leslie Kemeny
31	L and M Kemeny Consulting *North Korea's actions add up to nuclear blackmail* - article, The Canberra Times, 3 July 2003
32	L and M Kemeny Consulting *Nuclear power - a monster or a must?* - article, Mining Review, July 1982
33	L and M Kemeny Consulting *Australia standing at nuclear crossroads* - article by Prof Leslie Kemeny as read by Senator Towley, Senate Hansard, 5 April 1984, p.1337
34	L and M Kemeny Consulting *AAEC disrupted by Government muddling* - article, Sydney Morning Herald, 14 November 1986
35	L and M Kemeny Consulting *A costing of a lease of the nuclear fuel cycle* - article by Prof Leslie Kemeny, May 1978
36	L and M Kemeny Consulting *The truth about Australia's nuclear ambitions* - article by Richard Broinowski
37	L and M Kemeny Consulting *Emerging nuclear energy systems - a one hundred year perspective* - paper by Prof Leslie Kemeny, November 2001

38 L and M Kemeny Consulting
Stochastic techniques for the control and surveillance of a modular pebble bed reactor
- article by Prof Leslie Kemeny,
Progress in Nuclear Energy, Volume 43, 2003

39 L and M Kemeny Consulting
New nuclear scanning and surveillance systems for global security and safeguards
- paper by Prof Leslie Kemeny

40 L and M Kemeny Consulting
Physics - Nuclear Thermalization in Pulsed Moderators
- article, Prof Leslie Kemeny and M Williams,
Nature, 27 January 1962

41 Australian Bureau of Statistics (ABS)
Data relevant to the uranium industry
- information provided by the Australian Bureau of Statistics

42 L and M Kemeny Consulting
Emerging Nuclear Energy Systems:
A One Hundred Year Perspective
- article by Prof Leslie Kemeny

43 L and M Kemeny Consulting
Pseudo-science and Lost Opportunties
- article by Prof Leslie Kemeny,
Quadrant, July-August 2005

44 Environment Centre of the Northern Territory (ECNT)
Don't buy the NUCLEAR con - What is the solution to global warming? 6 reasons why it isn't nuclear power?

45 Institute of Public Affairs (IPA)
The Nuclear Power Debate
- article by M Nahan

46	Institute of Public Affairs (IPA) *The Economics of Nuclear Power* - article by Mr A Moran
47	Institute of Public Affairs (IPA) *The Safe Disposal of Nuclear Waste* - article by Mr T Quirk
48	Institute of Public Affairs (IPA) *Radioactive Waste Management in Australia* - article by Mr T Quirk
49	Uranium Information Centre (UIC) *Nuclear Industry in Europe* - paper by Ian Hore-Lacy
50	Victorian Branch of the Medical Association for Prevention of War (MAPW) *Risk of cancer after low doses of ionising radiation: retrospective cohort study in 15 countries* - article by E Cardis et al, sourced at BMJ.com
51	Victorian Branch of the Medical Association for Prevention of War (MAPW) *The Proliferation Consequences of Global Stocks of Separated Civil Plutonium* - paper by Dr Frank Barnaby, June 2005
52	Victorian Branch of the Medical Association for Prevention of War (MAPW) *Vulnerability of US Nuclear Power Plants to Terrorists* - issue brief of the Physicians for Social Responsibility, December 2003
53	Victorian Branch of the Medical Association for Prevention of War (MAPW) *Nuclear Terrorism* - article by Ira Helfand et al, BMJ Volume 324, 9 February 2002

54	Victorian Branch of the Medical Association for Prevention of War (MAPW) *Nuclear Power and the Terrorist Threat* - article by Molly Farneth for the Physicians for Social Responsibility
55	Victorian Branch of the Medical Association for Prevention of War (MAPW) *Dirty Bombs and Primitive Nuclear Weapons* - paper by Dr Frank Barnaby, June 2005
56	BHP Billiton *Olympic Dam Development Pre-feasibility Study* - study by BHP Billiton
57	Heathgate Resources Pty Ltd *Heathgate Resources Pty Ltd - Beverley Uranium Mine* - information by Heathgate Resources Pty Ltd
58	Minerals Council of Australia (MCA) *The Economics of Nuclear Power* - article by Alan Moran, Review, June 2005
59	Geoscience Australia Opening Remarks - by Dr Ian Lambert
60	Geoscience Australia *Australia's uranium resources, production & exploration* - Powerpoint presentation by Aden McKay and Dr Ian Lambert to Uranium Industry Framework, 11 August 2005
61	Geoscience Australia *Australia's uranium resources & exploration* - paper, Geoscience Australia, Uranium Industry Framework, Steering Group meeting, 11 August 2005

62	Geoscience Australia *Australia's Identified Mineral Resources 2005* - Geoscience Australia, Uranium Extract
63	Mr Lance Joseph *Multilateral approaches to the nuclear fuel cycle* - Issues brief by Mr Lance Joseph
64	Geodynamics *Correspondence from Geodynamics* - signed by Mr Bertus de Graaf
65	AMP Capital Investors Sustainable Funds Team *The Nuclear Fuel Cycle Position Paper* - by Sarah Kim & Dr Ian Woods, AMP Capital Investors Sustainable Funds Team (related to Submission No. 60)
66	Australian Nuclear Forum Inc (ANF) *Melbourne/Sydney flight gamma radiation profile* - graph, Gordon Mackenzie, RADSMART (related to Submission No. 11)
67	Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) *Radiation Protection & Radioactive Waste Management in Mining & Mineral Processing* - Radiation Protection Series No. 9, Australian Radiation Protection and Nuclear Safety Agency (related to Submission No. 32)
68	Dr Helen Caldicott *Nuclear power: economics and climate protection potential* - paper by Amory Lovens, CEO, Rocky Mountain Institute, 11 September 2005
69	Cameco Australia Pty Ltd - speech presented by Mr Jamie McIntyre, Director, Sustainable Development, Cameco Corporation, FSIN, April 2005

70	Cameco Australia Pty Ltd - speech presented by Chief Harry Cook , World Mining Ministers Conference, 6 March 2006
71	Friends of the Earth - Australia et al (FOE) *Nuclear Power - no solution to climate change* - paper by Dr Jim Green, Friends of the Earth (related to Submission No. 52)
72	Areva Group - graphs, Powerpoint presentation, Public Hearing, Perth, 23 September 2005
73	Dr Helen Caldicott *Nuclear Reactions - Nuclear Power for electricity generation keeps generating heated debate…* - article by Dr Helen Caldicott, IAFA Bulletin, No. 47/1, September 2005
74	Australian Nuclear Science and Technology Organisation (ANSTO) - Powerpoint presentation, Public Hearing, Canberra, 13 October 2005
75	Northern Territory Minerals Council Inc (NTMC) *Uranium Exploration and Mining Companies Working in the Northern Territory* - list
76	Energy Resources of Australia Ltd (ERA) *What is it really like to operate a large uranium mine in Australia?*' - speech presented by Mr Harry Kenyon-Slaney (related to Submission No. 46)
77	Summit Resources Ltd - Powerpoint presentation to the Committee by Summit Resources Limited, 3 November 2005 (related to Submission No. 15)

78	BHP Billiton *Olympic Dam* - Powerpoint presentation to the Committee, 2 November 2005
79	Victorian Branch of the Medical Association for Prevention of War (MAPW) *Safeguards and Plutonium Reprocessing* - paper by Prof Frank Barnaby, Oxford Research Group, October 2005 (related to Submission No. 31)
80	Heathgate Resources Pty Ltd *Sustainable Long Term Nuclear Power* by Mr Francesco Venneri and Mr E Michael Campbell, General Atomics, November 2005 (related to Submission No. 49)
81	BHP Billiton - answers to Questions-on-Notice, BHP Billiton, 22 November 2005
82	Energy Resources of Australia Ltd (ERA) *Ranger Overview* - Powerpoint presentation to the Committee, 25 October 2005 (related to Submission No. 46)
83	Australian International Thermonuclear Experimental Reactor Forum (ITER) - Powerpoint presentation, Public Hearing, 8 December 2005 (related to Submission No. 17)
84	Northern Territory Minerals Council Inc (NTMC) *Review of the Aboriginal Land Rights (NT) Act 1976 by John Reeves QC* - Submission of the NT Minerals Council (Inc), 22 January 1978 (related to Submission No. 51)

85	Australian International Thermonuclear Experimental Reactor Forum (ITER) *Prospects for economic fusions electricity* - paper by I Cook, RL Miller and DJ Ward, Fusion Engineering and Design, 2002 (related to Submission No. 17)
86	Northern Land Council (NLC) *Detailed Joint Submission to the Commonwealth Workability Reforms of the Aboriginal Land Rights(NT) Act 1976* - Northern Land Council (related to Submission No. 78)
87	Silex Systems Ltd *Response to Greenpeace Claims* - ASX Release, 25 November 2004
88	Silex Systems Ltd - Powerpoint presentation to the Committee, 9 February 2006
89	Friends of the Earth - Australia et al (FOE) - collection of media articles pertaining to uranium sales to China (related to Submission No. 52)
90	Prof Igor Bray *Thorium based fission* - Powerpoint presentation to the Committee, 2 March 2006
91	Mr Robert Gishubl *A cradle to grave concept for Australia's uranium* - article by Dr CJ Hardy (related to Submission No. 87)
92	Australian Safeguards and Non-Proliferation Office *Informal briefing concerning the United States Global Nuclear Energy Partnership (GNEP) Initiative* - presentation to the Committee, 1 June 2006

93 Australian Safeguards and Non-Proliferation Office
Informal briefing on the United States-India Nuclear Agreement
- presentation to the Committee, 1 June 2006

C

Appendix C — Public hearings and witnesses

Witnesses are listed in alphabetical order and under each public hearing day.

Thursday, 11 August 2005 - Canberra

Cameco Corporation

Mr Jerry Grandey, President and Chief Executive Officer

Dr Ron Matthews, Manager, Exploration

Friday, 19 August 2005 - Melbourne

Australian Conservation Foundation (ACF)

Mr David Noonan

Mr David Sweeney

Commonwealth Scientific Industrial Research Organisation (CSIRO)

Dr Roderick Hill, Group Executive, Information Manufacturing and Minerals

Friends of the Earth - Australia (FOE)

Dr Jim Green, National Nuclear Campaigner

Ms Michaela Stubbs, Campaigner Coordinator

Heathgate Resources Pty Ltd

Mr David Brunt, Vice President, Exploration and Development

Mr Mark Chalmers, Senior Vice President

Medical Association for Prevention of War (MAPW) (Victorian Branch)

Ms Dimity Hawkins, Executive Officer

Mr Lindsay Rayner

Assoc Prof Tilman Ruff, President, Victorian Branch

Individual

Dr Gavin Mudd

Southern Gold Ltd

Mr Ric Horn, Chairman

Uranium Information Centre (UIC)

Mr Ian Hore-Lacy, General Manager

Monday, 5 September 2005 - Canberra

Australian Bureau of Agricultural and Resource Economics (ABARE)

Mr Andrew Dickson, Manager, Commodity Outlook Branch

Mr Will Mollard, Senior Commodity Analyst

Geoscience Australia

Dr Ian Lambert, Acting Chief, Minerals Division

Mr Aden McKay, Principal Geologist, Minerals Division

Minerals Council of Australia (MCA)

Mr Mitchell Hooke, Chief Executive

Mr Peter Morris, Senior Director, Economic Policy

Mr Robert Rawson, Director, Safety and Health

Friday, 16 September 2005 - Sydney

Individuals

Mr Keith Alder

Prof Richard Broinowski

Dr Helen Caldicott

AMP Capital Investors Sustainable Funds Team

Dr Ian Woods, Senior Research Analyst

Australian Nuclear Association (ANA)

Dr Clarence Hardy, Secretary

Australian Nuclear Forum Inc (ANF)

Mr James Brough, President

Mr Jim Fredsall, Secretary

Dr Philip Moore, Committee Member

Australian Radiation Protection and Nuclear Safety Agency (ARPANSA)

Dr John Loy, Chief Executive Officer

Compass Resources Ltd

Dr Malcolm Humphreys, Executive Director

L and M Kemeny Consulting

Professor Leslie Kemeny

Friday, 23 September 2005 - Perth

Arafura Resources NL

Mr Alistair Stephens, Managing Director

Areva Group

Mr Damien Ewington, Regional Manager, Uranium

Mr Stephen Mann, General Manager, Cogema Australia Pty Ltd

Mr Jean-Pierre Nicoud, Vice President Operations, Cogema Resources Inc (Canada)

Association of Mining and Exploration Companies (AMEC)

Dr David Blight, Committee Member

Mr Alan Layton, Research and Policy Officer

Deep Yellow Ltd

Mr James Pratt, Managing Director

Eaglefield Holdings Pty Ltd

Mr Michael Fewster, Manager

Jindalee Resources Ltd

Mr Donald Kennedy, Chairman

Medical Association for the Prevention of War (MAPW) (WA Branch)

Dr Peter Masters, Member, Executive Committee

Nova Energy Ltd

Mr Richard Pearce, Managing Director

Dr Timothy Sugden, Chairman

Monday, 10 October 2005 - Canberra

Australian Safeguards and Non-Proliferation Office (ASNO)

Mr John Carlson, Director General

Mr Nick Doulgeris, Head, Nuclear Accountancy and Control Section

Department of Environment and Heritage (DEH)

Mr David Borthwick, Secretary

Mr Peter Cochrane, Director, National Parks

Mr Gerard Early, Assistant Secretary, Approvals and Wildlife Division

Mr Alan Hughes, Assistant Secretary, Supervising Scientist Division

Mr John Jende, Director, Renewable Energy Policy Energy Futures Branch

Dr Arthur Johnston, Supervising Scientist, Supervising Scientist Division

Mr Barry Sterland, First Assistant Secretary, Industry Communities and Energy Division

Ms Anthea Tinney, Deputy Secretary

Submarine Institute of Australia (SIA)

Rear Admiral (Rtd) Peter Briggs AO CSC, President

Mr John Thornton, Member

Mr Derrick Webster, Vice President, Business Development

Thursday, 13 October 2005 - Canberra

Australian Institute of Nuclear Science and Engineering (AINSE)

Prof Brian O'Connor, Vice President

Dr Dennis Mather, Scientific Secretary

Australian Nuclear Science and Technology Organisation (ANSTO)

Dr Ron Cameron, Chief of Operations

Dr Ian Smith, Executive Director

Monday, 24 October 2005 - Darwin

Energy Resources of Australia Ltd (ERA)

Mr Harry Kenyon-Slaney, Chief Executive Officer

Northern Land Council (NLC)

Mr John Daly, Chairman

Mr Norman Fry, CEO

Mr Ron Levy, Principal Legal Officer

Mr John Sheldon, Senior Policy Officer

Mr Howard Smith, Special Projects Officer, Environment and Engineering

Northern Territory Government

Mr Richard Jackson, Director of Compliance, Minerals and Energy Group

Mr Richard Sellars, A/g Executive Director, Minerals and Energy Group

Mr Keith Tayler, Uranium Adviser, Minerals and Energy Group

Northern Territory Minerals Council Inc (NTMC)

Mr Neville Henwood, Executive Committee Member

Dr Ron Matthews, Manager, Exploration, Cameco Australia Pty Ltd

Ms Kezia Purick, Chief Executive Officer

The Environment Centre NT Inc (ECNT)

Mr Peter Robertson, Coordinator

Dr Gary Scott, Freshwater Project Officer

Wednesday, 2 November 2005 - Canberra

BHP Billiton Ltd

Mr Bernie Delaney, Vice President, Government Relations and Asset Protection

Mr Steve Green, Sustainability Manager, Olympic Dam Development Study

Dr Richard Higgins, Vice-President and Chief Operating Officer,

Base Metals Australia

Mr Richard Yeeles, Group Manager, Corporate Affairs, Base Metals Australia

Thursday, 3 November 2005 - Canberra

Summit Resources Ltd

Mr Alan Eggers, Managing Director

Thursday, 8 December 2005 - Canberra

Australian Australian International Thermonuclear Experimental Reactor Forum (ITER)

Dr Matthew Hole, Chair

Prof John O'Connor, Spokesperson

Australian National University

Dr Boyd Blackwell, Facility Director, Research School of Physical Sciences and Engineering

Thursday, 9 February 2006 - Canberra

Silex Systems Ltd

Mr Michael Goldsworthy, Chief Executive Director

Mr Christopher Wilks, Director

Thursday, 2 March 2006 - Canberra

Individual

Prof Igor Bray

D

Appendix D — World nuclear power reactors

The following table, published by the World Nuclear Association, lists the world's nuclear power reactors operating in 2004–06, the amount of electricity generated in 2004, reactors under construction, planned and proposed, and their uranium requirements as at 25 May 2006.

World nuclear power reactors 2004–06 and uranium requirements, as at 25 May 2006

	NUCLEAR ELECTRICITY GENERATION 2004–05		REACTORS OPERABLE May 2006		REACTORS under CONSTRUCTION May 2006		REACTORS PLANNED May 2006		REACTORS PROPOSED May 2006		URANIUM REQUIRED 2006
	billion kWh	% e 2005	No.	MWe	No.	MWe	No.	MWe	No.	MWe	tonnes U
Argentina	7.3	6.9	2	935	1	692	0	0	0	0	134
Armenia	2.2	43	1	376	0	0	0	0	1	1000	51
Belgium	44.9	56	7	5 728	0	0	0	0	0	0	1 075
Brazil	11.5	2.5	2	1 901	0	0	1	1 245	0	0	336
Bulgaria	15.6	44	4	2722	0	0	2	1 900	0	0	253
Canada	85.3	15	18	12 595	0	0	2	1 540	0	0	1 635
China	47.8	2.2	10	7 587	5	4 170	5	4 600	19	15 000	1 294
Czech Republic	26.3	31	6	3 472	0	0	0	0	2	1 900	540
Egypt	0	0	0	0	0	0	0	0	1	600	0
Finland	21.8	33	4	2 676	1	1 600	0	0	0	0	473
France	426.8	79	59	63 473	0	0	1	1 630	1	1 630	10 146
Germany	158.4	31	17	20 303	0	0	0	0	0	0	3 458
Hungary	11.2	37	4	1 755	0	0	0	0	0	0	251

India	15.0	2.8	15	2 993	8	3 638	0	0	24	13 160	1 334
Indonesia	0	0	0	0	0	0	0	0	4	4 000	0
Iran	0	0	0	0	1	915	2	1 900	3	2 850	0
Israel	0	0	0	0	0	0	0	0	1	1 200	0
Japan	273.8	29	55	47 700	1	866	12	14 782	0	0	8 169
Korea DPR (North)	0	0	0	0	1	950	1	950	0	0	0
Korea RO (South)	124.0	38	20	16 840	0	0	8	9 200	0	0	3 037
Lithuania	13.9	72	1	1 185	0	0	0	0	1	1 000	134
Mexico	10.6	5.2	2	1 310	0	0	0	0	2	2 000	256
Netherlands	3.6	3.9	1	452	0	0	0	0	0	0	112
Pakistan	1.9	2.4	2	425	1	300	0	0	2	1 200	64
Romania	5.1	8.6	1	655	1	655	0	0	3	1 995	176
Russia	133.0	16	31	21 743	4	3 600	1	925	8	9 375	3 439
Slovakia	15.6	56	6	2 472	0	0	0	0	2	840	356
Slovenia	5.2	42	1	676	0	0	0	0	0	0	144
South Africa	14.3	5.5	2	1 842	0	0	1	165	24	4 000	329
Spain	60.9	20	8	7 442	0	0	0	0	0	0	1 505

Sweden	75.0	47	10	8 938	0	0	0	0	0	0	1 435
Switzerland	25.4	32	5	3 220	0	0	0	0	0	0	575
Turkey	0	0	0	0	0	0	0	0	3	4 500	0
Ukraine	81.1	49	15	13 168	0	0	2	1 900	0	0	1 988
United Kingdom	73.7	20	23	11 852	0	0	0	0	0	0	2 158
USA	788.6	19	103	98 034	1	1 065	0	0	13	17 000	19 715
Vietnam	0	0	0	0	0	0	0	0	2	2 000	0
WORLD**	**2 618.6**	**16**	**441**	**369 374**	**27**	**21 361**	**38**	**40 737**	**115**	**83 620**	**65 478**
	billion kWh	**% e**	**No.**	**MWe**	**No.**	**MWe**	**No.**	**MWe**	**No.**	**MWe**	**tonnes U**
	NUCLEAR ELECTRICITY GENERATION 2004–05		**REACTORS OPERATING**		**REACTORS BUILDING**		**ON ORDER or PLANNED**		**PROPOSED**		**URANIUM REQUIRED**

Source World Nuclear Association, *World Nuclear Power Reactors 2004-06 and Uranium Requirements* (as at 25 May 2006), viewed 1 June 2006, <http://www.world-nuclear.org/info/reactors.htm>.

Notes:
Building/Construction = first concrete for reactor poured, or major refurbishment under way
Planned = Approvals and funding in place, or construction well advanced but suspended indefinitely
Proposed = clear intention but still without funding and/or approvals
TWh = Terawatt-hours (billion kilowatt-hours)
MWe = Megawatt electrical (electrical as distinct from thermal)
kWh = kilowatt-hour.
Total uranium required: 65 478 t U = 77 218 t U_3O_8

** The world total includes 6 reactors on Taiwan with a combined capacity of 4 884 MWe, which generated a total of 37.9 TWh in 2004 (accounting for 21 per cent of Taiwan's total electricity generation). Taiwan has two reactors under construction with a combined capacity of 2 600 MWe.

E

Appendix E — Australia's uranium ore reserves and mineral resources

The following tables, prepared by Geoscience Australia, list the uranium ore reserves and mineral resources for Australian uranium deposits as reported by the mining companies as at December 2005. Australia's seven largest deposits are shown in bold.

Northern Territory

DEPOSIT	RESERVES / RESOURCES[(a) (b)]	GRADE % U_3O_8	CONTAINED U_3O_8 (Tonnes)
Alligator Rivers Region			
Ranger No 3 Orebody	**Ore Reserves** **Mineral Resources**	**0.20** **0.14**	**44 457** **42 587**
Jabiluka 1	Mineral Resources	0.25	3 400
Jabiluka 2	**Ore Reserves**	**0.52**	**67 000**
	Mineral Resources	**0.46**	**96 000**
Koongara No 1 Orebody	**Ore Reserves**	**0.8**	**14 500**
Koongara No 2 Orebody	Mineral Resources	0.3	2 000
Hades Flat	Mineral Resources		726
Ranger 4	Mineral Resources		200
Ranger 68 (Barote)	Mineral Resources	0.357	5 500
South Alligator Valley			
Coronation Hill	Mineral Resources	0.537	1 850
El Sherana West	Mineral Resources		80
Allamber Region			
Twin and Dam	Mineral Resources	0.13	746
Oenpelli Region			
Caramal	Mineral Resources		2 500
Rum Jungle Region			
Mt Fitch and Rum Jungle Creek South deposits and Dyson's Dump	Combined Resources	0.04	2 344
Amadeus Basin			
Angela	Mineral Resources	0.1	10 250
Ngalia Basin			
Bigrlyi	Mineral Resources	0.343	2 774
Walbiri	Mineral Resources	0.162	686
Pandanus Creek			
Eva	Mineral Resources		363
Arunta Complex			

DEPOSIT	RESERVES / RESOURCES[(a) (b)]	GRADE % U_3O_8	CONTAINED U_3O_8 (Tonnes)
Nolans Bore	Mineral Resources	0.02	3 977
Total for Northern Territory			**301 940**

South Australia

DEPOSIT	RESERVES / RESOURCES[(a) (b)]	GRADE % U_3O_8	CONTAINED U_3O_8 (Tonnes)
Gawler Craton			
Olympic Dam	**Ore Reserves** [(c)]	**0.05**	**389 500**
	Mineral Resources [(d)]	**0.04**	**1 075 500**
Prominent Hill	Mineral Resources	0.012	9 990
Frome Embayment			
Beverley	Ore Reserves		12 258
Honeymoon	Mineral Resources	0.12	3 300
East Kalkaroo	Mineral Resources	0.074	910
Goulds Dam	Mineral Resources	0.045	2 500
Billeroo	Mineral Resources	0.03	3 600
Flinders Ranges			
Radium Ridge	Mineral Resources	0.06	2 177
Mt Gee	Mineral Resources	~0.073	33 200
Armchair, Streitberg Ridge	Mineral Resources	0.1	1 814
Olary District			
Mt Victoria	Mineral Resources	0.16	400
Crocker Well	Mineral Resources	0.51	6 338
Warrior	Mineral Resources	0.034	4 000
Total for South Australia			**1 545 487**

Queensland

DEPOSIT	RESERVES / RESOURCES [(a)] [(b)]	GRADE % U_3O_8	CONTAINED U_3O_8 (Tonnes)
Mount Isa Region			
Valhalla	**Mineral Resources**	**0.125**	**25 600**
Skal	Mineral Resources	0.119	5 000
Andersons Lode	Mineral Resources	0.143	6 500
Mirrioola	Mineral Resources	0.112	241
Warwai	Mineral Resources	0.12	120
Bikini	Mineral Resources	0.139	240
Watta	Mineral Resources	0.45	1 900
Highlander	Mineral Resources		90
Other small deposits	Combined Resources		34
Mary Kathleen Region			
Mary Kathleen	Mineral Resources		1 200
Georgetown Region			
Maureen	Mineral Resources	0.123	2 940
Trident	Mineral Resources	0.22	495
Twogee	Mineral Resources	0.12	755
Fourgeo	Mineral Resources	0.077	1 171
Oasis, Gecko, Sybnac	Combined Resources		171
Westmoreland			
Redtree, Junnagunna			
Huarabagoo, Sue and Outcamp	Mineral Resources	0.13	22 520
Hervey Ranges			
Ben Lomond	Mineral Resources	0.246	4 758
Total for Queensland			**73 735**

Western Australia

DEPOSIT	RESERVES / RESOURCES [(a) (b)]	GRADE % U_3O_8	CONTAINED U_3O_8 (Tonnes)
Paterson Province			
Kintyre	**Mineral Resources**	**0.15–0.4**	**36 000**
Canning Basin			
Oobagooma	Mineral Resources (recoverable)		5 000
Yilgarn Craton – Calcrete Deposits			
Yeelirrie	**Ore Reserves**	**0.15**	**52 500**
Centipede (includes Abercrombie and Millipede)	Mineral Resources	0.063	4 400
Lake Austin	Mineral Resources	0.08	151
Lake Maitland (Mt Joel)	Mineral Resources	0.052	7 900
Lake Raeside	Mineral Resources	0.025	1 700
Lake Way	Mineral Resources		4 000
Nowthana	Mineral Resources	0.086	2 023
Thatchers Soak	Mineral Resources	0.03	4 100
Lake Mason	Mineral Resources	0.035	2 700
Carnarvon Basin			
Manyingee	Mineral Resources	0.09	12 078
Bennets Well	Mineral Resources	0.16	1 500
Eucla Basin			
Mulga Rock	Mineral Resources	0.14	15 330
Total for Western Australia			**149 382**
TOTAL FOR AUSTRALIA			**2 070 544**

Notes:

(a) Mineral Resources are in addition to Ore Reserves (i.e. Mineral Resource figures are exclusive of those resources which have been modified to produce Ore Reserves).

(b) Mineral Resource figures are the sum of resources in the measured, indicated and inferred categories.

(c) As at 30 June 2005.

(d) As at 30 June 2005.

Definitions of Ore Reserves and Mineral Resources are provided in chapter three of the report and in the glossary.

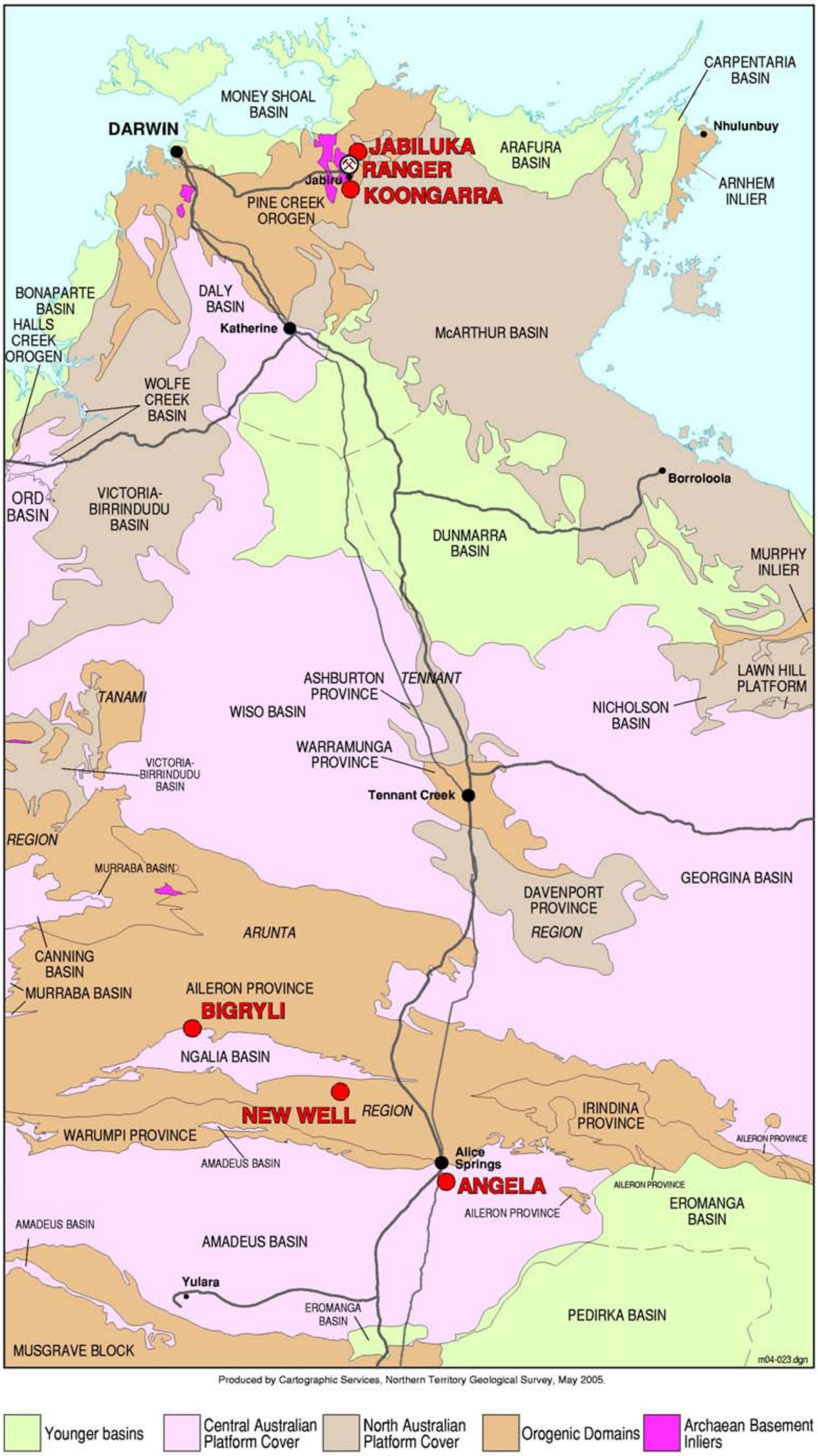
F

Appendix F — Uranium deposits of the Northern Territory

The map on the following page, submitted by the Northern Territory Minerals Council (NTMC), shows the major known uranium deposits in the Northern Territory and their geological provinces and settings.[1]

1 NTMC, *Submission no. 51*, p. 11.

URANIUM DEPOSITS OF THE NORTHERN TERRITORY



G

Appendix G — Management of radioactive waste

The following table indicates the measures that selected countries have in place or planned to store, reprocess and dispose of used nuclear fuel and other radioactive wastes.

Country	Policy	Facilities and progress towards final repositories
Belgium	Reprocessing	Central waste storage and underground laboratory established. Construction of repository to begin about 2035
Canada	Direct disposal	Underground repository laboratory established. Repository planned for use in 2025
China	Reprocessing	Central used fuel storage in LanZhou
Finland	Direct disposal	Used fuel storages in operation. Low and intermediate-level repositories in operation since 1992. Site near Olkiluoto selected for deep repository for used fuel from 2020
France	Reprocessing	Two facilities for storage of short-lived wastes. Site selection studies underway for deep geological repository for commissioning in 2020
Germany	Reprocessing but moving to direct disposal	Low-level waste sites in use since 1975. Intermediate-level wastes stored at Ahaus. Used fuel storage at Ahaus and Gorleben. High-level repository to be operational after 2010
India	Reprocessing	Research on deep geological disposal for high-level waste

Japan	Reprocessing	Low-level waste repository in operation. High-level waste storage facility at Rokkasho-mura since 1995. Investigations for deep geological repository site begun, to operate from 2035
Russia	Reprocessing	Sites for final disposal under investigation. Central repository for low and intermediate-level wastes planned from 2008
South Korea	Direct disposal	Central interim high-level waste store planned for 2016. Central low and intermediate-level repository planned from 2008. Investigating deep high-level waste repository sites.
Spain	Direct disposal	Low and intermediate-level waste repository in operation. Final high-level waste repository site selection program for commissioning in 2020
Sweden	Direct disposal	Central used fuel storage facility in operation since 1985. Final repository for low to intermediate waste in operation since 1988. Underground research laboratory for high-level waste repository. Site selection for repository in two volunteered locations.
Switzerland	Reprocessing	Central interim storage for high-level wastes at Zwilag since 2001. Central low and intermediate-level storages operating since 1993. Underground research laboratory for high-level waste repository, with deep repository to be finished by 2020
United Kingdom	Reprocessing	Low-level waste repository in operation since 1959. High-level waste is vitrified and stored at Sellafield. Underground high-level waste repository envisaged.
United States	Direct disposal but moving to reprocessing	Three low-level waste sites in operation. Decision in 2002 to proceed with Yucca Mountain geological repository for 70,000 tonnes used fuel & HLW.

Source Uranium Information Centre, *Submission no. 12*, pp. 41–42.

H

Appendix H — World enrichment plants

The following table, adapted and updated from the *World Nuclear Industry Handbook 2006*, published by Nuclear Engineering International, lists the world's uranium enrichment plants, their status, the technology employed, operator, nameplate capacity in separative work units (SWU) per year, annual production, year of start up of commercial operation/proposed date, and date of shutdown.

World uranium enrichment plants

Country / plant	Status	Process	Operator	Capacity (SWU/year)	Annual production (SWU)	Start of operation / proposed start date	Date of shut down
Argentina							
Pilcaniyeu (Phase 2)	★	Diffusion	NASA	100 000			
Pilcaniyeu (Phase 1)	•	Diffusion	NASA	20 000			
Brazil							
Sorocaba	+	Centrifuge	IPEN				
Resende[4]	•	Centrifuge	INB	115 000		2006	
Resende Jet Nozzle Plant	Ø	Jet nozzle					
France							
Georges Besse Plant	•	Diffusion	Eurodif	10 800 000		1982	2012–13
Georges Besse II[3]	★	Centrifuge	Areva	7 500 000		2009	
Germany							
Gronau	•	Centrifuge	Urenco	1 800 000		08/85	
Iran							
Natanz	•						
Japan							
Hyuga	•	Chemical	Asahi Chemical Industry Co	2 000	0	12/86	
Ningyo-Toge (Pilot)	•	Centrifuge	JAEA			1982	
Uranium Enrichment Plant (Rokkasho)	•	Centrifuge	JNFL	1 500 000		03/92	
Ningyo-Toge (Demonstration)	□	Centrifuge	JAEA	200 000 kgswu/y		1989	

Netherlands							
Almelo SP3	•	Centrifuge	Urenco	100 000	100 000	01/73	
Almelo SP4	•	Centrifuge	Urenco	1 500 000	1 400 000	01/80	
Almelo SP5	•	Centrifuge	Urenco	1 000 000	500 000	05/00	
Pakistan							
Kahuta[5]	•	Centrifuge	PAEC	5 000		1984	
Russia							
Angarsk	•	Centrifuge	Minatom	2 000 000		1954	
Ekaterinberg (Sverdlovsk)	•	Centrifuge	UEC (Minatom)	9 000 000		1949	
Krasnoyarsk-45	•	Centrifuge	EP (Minatom)	5 000 000		1964	
Tomsk 7	•	Centrifuge	SCC (Minatom)	3 000 000			
South Africa							
Valindaba (Pelindaba East)	□	Helikon	UCOR	300 000		1982	
United Kingdom							
E21	•	Centrifuge	Urenco	1 100 000	1 100 000	11/76	

USA							
Paducah, Kentucky	●	Diffusion	USEC	11 300 000	5 400 000	12/54	
Portsmouth, Ohio (Gaseous Diffusion Plant)	□	Diffusion	USEC	7 400 000	6 400 000	11/55	2001
Oak Ridge	□	Diffusion	Exxon	7 700 000	0	1945	1985
Eunice, New Mexico[1]	★	Centrifuge	LES	3 000 000		2008	
Piketon, Ohio[2]	★	Centrifuge	USEC	3 500 000		2007	

Source Nuclear Engineering International (Wilmington Publishing), *World Nuclear Industry Handbook 2006,* p. 217. Updated with information provided by the Australian Uranium Association.

1 First production from the US 'National Enrichment Facility' at Eunice, New Mexico, is expected in 2008, with full capacity of 3 million SWU per year being reached in 2013.
2 The main centrifuge plant at Piketon Ohio, being constructed by USEC, has a planned initial capacity of 3.5 million SWU from 2011, with a license application for 7 million SWU to allow for expansion.
3 The Georges Besse II plant in France is expected to start operation in 2009, and expand to full capacity of 7.5 million SWU per year in 2018.
4 The capacity of the Resende plant in Brazil is expected to be expanded to 200 000 SWU per year.
5 The capacity of the Kahuta plant in Pakistan is expected to be expanded to approximately 150 000 SWU per year.

Status: ● = operable
★ = under construction
□ = shut down / decommissioned
+ = proposed
Ø = suspended