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]**.