Developing Australia's non-fossil fuel energy industry

House of Representatives Standing Committee on Industry and Resources

CSIRO submission

May 2005

Contact: Dr Rod Hill, Group Executive
Information, Manufacturing and Minerals Group
Box 312, Clayton South VIC 3169
Phone: 03 9545 8300
Email: rod.hill@csiro.au

Dr Steve Morton, Group Executive
Sustainable Energy and Environment Group
Box 2697, Canberra ACT 2601
Phone: 02 6246 4552
Email: steve.morton@csiro.au

Acronyms used

ANSTO	Australian Nuclear Science and Technology Organisation
CRC	Cooperative Research Centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
IAEA	International Atomic Energy Agency
NPT	Nuclear Non-Proliferation Treaty
OECD	Organisation for Economic Co-operation and Development
U_3O_8	Uranium oxide (unprocessed raw material)
Zeolite	A porous mineral able to absorb/incorporate other elements

Table of contents

Executive Summary

- Australia's production of Uranium oxide has risen to more than 10,000 tU/annum in response to a price increase since 2002.
- Uranium demand is expected to increase even more, considering the predicted global energy demand.
- Australia and Canada dominate the world's known Uranium deposits, with all of Australian production being exported.
- Australian exports over the last four years have provided about 25% of the world Uranium supply from mines and is sold strictly for electrical power generation only.
- With almost half the known low-cost Uranium resources in the world, Australia has the potential to strengthen its market position.
- Many prospective Uranium deposits are located in culturally or environmentally sensitive regions of Australia, making access challenging.
- The majority of Australia's Uranium reserves is expected to cost less than US$40 per kg to extract, which is under the cost threshold, but its production lags substantially behind that of Canada.
- Australia's ability to increase the strategic value of its Uranium resources lies in more efficient delivery to the market place.
- Future discoveries of Uranium will require more sophisticated geochemical and geophysical technologies.
- Research is leading towards both more productive means of extraction and more effective means of reducing environmental impacts.
- Australia could consider extending its technological operations significantly along the Uranium fuel value chain. Within CSIRO and ANSTO there are the necessary research skills to support this.
- Uranium assets and legacy holdings should be monitored and protected to responsibly minimise long-term environmental impacts.
- Whilst skills for developing the Uranium industry are currently available, coordination of existing skills around Australia would be necessary to establish a critical mass in support of industry innovation.
- Consideration would need to be given to the training and development of the next generation of researchers.
- The Energy Transformed National Research Flagship Program is modelling the impacts of various scenarios for energy generation to 2050 as part of its Energy Futures Forum.
- The scenarios are being assembled by representative leaders from a diverse grouping of industry, government, environmental, consumer, employee and social services entities. It is difficult to conceive a more legitimate group to put together plausible scenarios of our energy future.
- The postulation of a future in which nuclear power plays a significant role is part of the debate currently underway within this Forum. The outcomes of this study – due in 2006 – will form a credible basis for informing policy formulation and industry decision-making.

Introduction

This submission outlines the strategic importance of Australia's Uranium resources and suggests strengths and weaknesses in the resource base and Australia's supporting research capability that could be applied to further develop and capture value from this resource base.

The terms of reference for the inquiry specifically raise the issues of:

1. potential implications for global greenhouse gas emission reductions from the further development and export of Australia's Uranium resources; and
2. global demand for Australia's Uranium resources and associated supply issues;
3. strategic importance of Australia's Uranium resources and relevant industry developments;
4. current structure and regulatory environment of the Uranium mining sector

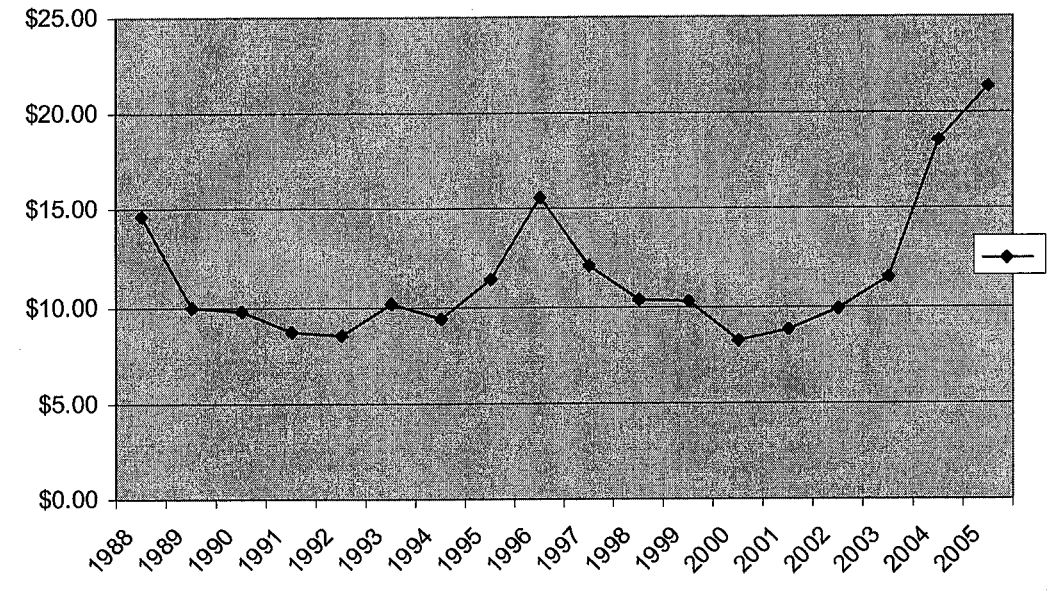
This submission focuses briefly on the first term of reference, and then continues to address terms of reference 2 and 3 and to a lesser extent the regulatory environment of the Uranium mining sector.

Understanding the facts of global demand for Australia's uranium resources

Rise in global demand and its causes

The International Atomic Energy Agency (IAEA) and the Organisation for Economic Co-operation and Development (OECD) formally document the supply and demand for Uranium for nuclear energy production every two years. The last edition of the Red Book, "*Uranium 2003: Uranium resources Production and Demand*", was published in 2003 based on figures to the end of 2002.

Figure 1 **Average Annual U_3O_8 Price US$/Pound**



At that time the Uranium oxide price averaged US$10/pound and was just recovering from a 15-year low. Since then the price has risen to more than US$20/pound Uranium oxide – an all time high price (see Figure 1). In response to the price increase, Australia's production has risen to more than 10,000 tU /annum.

At the end of 2002 global demand for Uranium was predicted to increase to between 73,500 and 86,000 tU by 2020 (IAEA 2003) However, Uranium demand may increase even more, considering the predicted enormous global energy demand in that timeframe and the potential for nuclear power to reduce greenhouse gas emissions. Current developments in China and India, which are both planning to build a number of reactors by 2020, are driving up the price of Uranium globally. The 2005 Red Book, to be published this year, will incorporate data up to the end of 2004 and will provide an updated prediction of Uranium demand to 2020 and beyond.

Based on 2002 rates of utilisation, reactor technologies and market context, known resources will last for around 270 years (Uranium Information Centre website), but given recent trends it is unlikely that current rates of utilisation will remain unchanged. The debate about oil depletion and the question as to whether an oil peak (rollover) is imminent are adding impetus to the drive towards a hydrogen economy. This development could in part be aided by nuclear power generation for electricity which could then be used for splitting water into its component parts, hydrogen and oxygen. If this trend continues, it would increase global Uranium utilisation rates radically. However, this possibility would need to be paralleled by a global industry in re-processing of Uranium fuel, and by an alteration in the current general public antipathy towards nuclear power generation.

Extent of resources in Australia

Australia and Canada dominate the world's known Uranium deposits. There are at present three Uranium mines operating in Australia: Ranger in the Northern Territory and Olympic Dam and Beverley in South Australia. A fourth mine has been cleared to start construction: Honeymoon in South Australia.

All Australian production is exported. During 2002/03, Australia produced 9,148 tonnes (t) of Uranium concentrate (U_3O_8), representing 19% of global output, valued at A$427 million. During the calendar year 2004 production of Uranium comprised: 5,137 t from Ranger; 4,370 t from Olympic Dam and 1,084 t from Beverley – a total of 10,591 t. The value of exports has varied over the last few years between A$350-450 million.

Supply issues

Australian exports over the last four years have averaged almost 7500 tonnes per year of uranium, providing about 25% of world uranium supply from mines. Uranium comprises 42% of the country's energy exports (4066 PJ in 2002-03) in thermal terms.

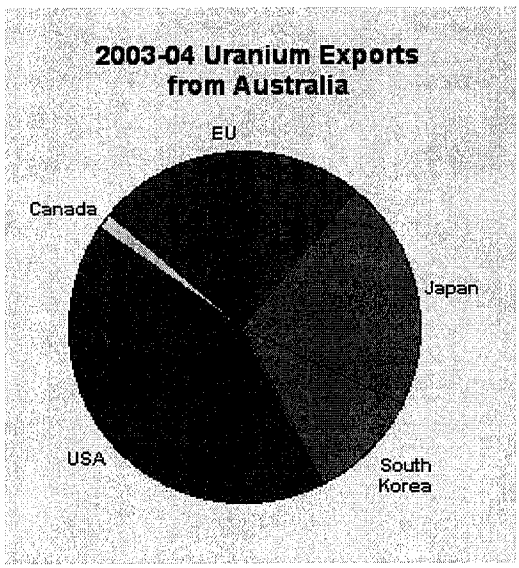


Figure 2
Chart and following data from UIC Website (http://www.uic.com.au/nip01-inf48.htm)

In the five years to mid 2003 Australia exported 40,693 tonnes of Uranium Oxide concentrate (34,506 tU) with a value of over A$1.9 billion. The nations which currently purchase Australia's uranium are set out below. All have a large commitment to nuclear power:

USA: circa 3000 t per year - 104 reactors (supplying 20% of electricity).

Japan: circa 3000 t per year - 54 reactors (supplying 34% of electricity)

South Korea: circa 1000 t per year - 17 reactors (39% of electricity)

EU: about 800 t per year, including:
Spain: 9 reactors (29% of electricity)
France: 59 reactors (77% of electricity)
UK: 31 reactors (23% of electricity)
Sweden: 11 reactors (44% of electricity)
Germany: 19 nuclear reactors (31% of electricity)
Belgium: 7 reactors (58% of electricity)
Finland: 4 reactors (31% of electricity)

The majority of the increased Uranium demand is likely to come from China and India.

Impact of regulatory regimes

Australia's uranium is sold strictly for electrical power generation only. Australia is a party to the Nuclear Non-Proliferation Treaty (NPT) as a non-nuclear weapons state. Its safeguards agreement under the NPT came into force in 1974 and it was the first country in the world to bring into force the Additional Protocol in relation to this in 1997.

Relationships with those countries to which Australia supplies Uranium

Some of the greatest challenges to Uranium extraction lie in the socio-political domain, as the activity cannot be divorced from the issue of nuclear power generation, even if the power generation occurs in another country.

Several important questions need to be asked in this socio-political domain. If we expand our production, are we necessarily going to export more to the same countries to which our supplies currently go, or are we likely to export to additional countries? If we export to new countries, what political factors need to be taken into account?

Strategic importance of Australia's uranium resources

Cost of production and cost threshold

With almost half the known low-cost Uranium resources in the world, Australia has the potential to strengthen its market position if nuclear power generation comes back to the forefront of the energy debate. If Australia could add value by sourcing new deposits of Uranium and by enabling greater levels of recovery from known deposits through innovative technology, it could position itself as the global leader.

Cost issues are not completely straightforward though. There is evidence that the Uranium market has a cost threshold of $40 per kg U (IAEA 2003). The majority of Australia's Uranium reserves are expected to cost less than US$40 per kg to extract, which gives Australia a substantial advantage in the global market. However, whilst Australia has much higher reserves in this cost category than any other country, its production lags substantially behind that of Canada.

Australia has over 40% of the world's lowest-cost uranium resources (under US$ 40/kg). Nearly all of Australia's 667 000 tonnes of Reasonably Assured Resources of uranium alone (to US $30/lb U_3O_8 or $80/kg U) are in the under US$ 40/kg U category. This compares with Kazakhstan (327 000 t), Canada (315 000 tonnes), South Africa (231 000 tonnes) and Namibia (144 000 tonnes). The following table shows these plus Estimated Additional Resources.

Known Recoverable Resources of Uranium*

	tonnes U	percentage of world
Australia	863,000	28%
Kazakhstan	472,000	15%
Canada	437,000	14%
South Africa	298,000	10%
Namibia	235,000	8%
Brazil	197,000	6%
Russian Federation	131,000	4%
USA	104,000	3%
Uzbekistan	103,000	3%
World total	**3,107,000**	

* *Reasonably Assured Resources plus Estimated Additional Resources - category 1, to US$ 80/kg U, 1/1/01, from OECD NEA & IAEA,* Uranium 2001: Resources, Production and Demand. *Brazil, Kazakhstan, Uzbekistan and Russian figures above are 75% of* in situ *totals.*

Australia's ability to increase the strategic value of its Uranium resources lies in the ability to deliver it efficiently to the market place.

Potential for increased efficiency

Four specific areas of the Uranium value chain, where science could contribute to greater efficiencies, are considered below.

- Exploration – supporting the discovery of new resources and adding strategic value;
- extraction – supporting the extraction of Uranium from the ground;
- adding value – supporting the processing of Uranium into a useable commodity; and,
- life-time stewardship – supporting the management of waste in terms of safe storage, reprocessing and/or recycling.

Exploration

Although Australia has a large proportion of the world's current low cost Uranium, increasing demand over the next decade will drive exploration internationally for lower cost, higher value resources. If companies in Australia do not undertake further exploration for such resources, then our international competitiveness is likely to be eroded. Exploration activity has already started to increase in Australia following a period of almost 15 years of inactivity.

The major technical problems relate to the exploration maturity of the most prospective terranes such as the Alligator Rivers Province of the Northern Territory. The more easily detected, near-surface mineralisation has already been found and future discoveries will require more sophisticated geochemical and geophysical technologies to look at greater depth as well as a more thorough understanding of how such mineralisation forms.

In this context, CSIRO could play a role if necessary in the development of methodologies and technologies for predicting the likely location of mineralisation in particular terrains. The Organisation also has the capability to develop and apply new geochemical and geophysical detection technologies specifically for Uranium exploration.

Extraction

Research is leading towards both more productive means of extraction and more effective means of reducing environmental impacts.

Uranium mining methods are changing and evolving on the basis of experience here and in Canada. The recently authorised Honeymoon Uranium mine is based on an *in situ* leaching method that avoids the need for significant Uranium mine tailings[1]. Uranium mine tailings represent a radioactive hazard on a par with or exceeding that associated with radioactive waste. Significant Canadian science investment is now being made in the area of Uranium tailings management. The legacy issues from Uranium mining should not be underestimated.

Adding value

As with most raw materials, significant value add occurs when the raw material is processed and refined. Currently, Australia undertakes no form of Uranium processing or enrichment.

However, there is significant experience in CSIRO and ANSTO (both in collaboration and independently) in the area of removal of radioactivity from mineral sands and other materials and in the treatment of leach products.

In short, if Australia wishes to extend its technological operations significantly along the Uranium fuel value chain, there are the necessary research skills within CSIRO and ANSTO to support such developments.

However, if Australia progressed its technology and offered services extending beyond the mining and upgrading of Uranium ore, it could not do so without considering a wide range of implications.

Lifetime stewardship

Stewardship implies that the full lifecycle of a resource is addressed responsibly to minimise long-term environmental impacts.

1 The waste material from a Uranium mill after the uranium has been extracted from the ore. Tailings contain the radioactive decay products of Uranium mixed with a large volume of non-radioactive rock, all in a finely ground form and mixed with water.

There is significant expertise in the Australian research community to address these issues. In particular, CSIRO has an emerging capability in sustainable mining, is a Foundation Partner in the new Sustainable Resource Processing CRC, and has a major focus on waste reduction, recycling and amelioration of wastes.

In the Uranium industry, this concept leads towards the consideration of how radioactive wastes are managed and how nuclear assets are to be secured.

With the emerging concern over terrorist attacks on critical infrastructure and strategic resources around the world, an additional dimension to the lifetime stewardship challenge is the need to monitor and protect these Uranium assets and legacy holdings. Australia is currently developing and marshalling a strong capability in a wide range of counter terrorism initiatives, many of which might be suitable for application to the Uranium value chain.

Socio-political issues

Accessing Australia's known energy resources has some significant socio-political challenges. Many prospective Uranium deposits are located in culturally or environmentally sensitive regions of Australia, and there have been particular issues regarding relationships with indigenous Australians over many years.

Development of enhanced techniques for nuclear waste disposal

The major issue that is inevitably linked to the production and exportation of Uranium is the disposal of radioactive waste. Regulating radioactive waste disposal requires an operator to meet safety criteria for very long timescales into the future.

Most countries adopt the principle that radioactive wastes should be disposed of by the countries that create them. However, this requires a high-level domestic science and engineering capability. In Australia, international collaboration on the science of radioactive waste management is very high and ANSTO already has a significant global reputation in many areas of radioactive handling. CSIRO also has expertise in this domain and could contribute in areas complementary to ANSTO's existing expertise. Key prospective areas for such potential contributions to Australia's nuclear science and technology capabilities are:

- material development to increase the lifetime and performance of materials of construction and containment used in the nuclear industry
- chemical processing to reduce the escape of certain waste forms into the environment;
- the customisation of the properties of zeolite materials used for the capture and retention of radioactive organic species that may not have high levels of sorption onto clay and rock surfaces used traditionally for containment materials;
- more efficient and effective handling systems to promote the ability of disposing of radioactive wastes;
- integrated modelling of fluid flow and solute transport to allow development of more effective management systems and better understanding of
- geotechnical impacts and two phase gas migration;
- linking physical models of groundwater flow and radionuclide transport to biosphere models of plant uptake and human ingestion; and
- linking process models to risk models.

Skills required for developing the industry and current shortage

Coordination of existing skills around Australia would be necessary to establish a critical mass in support of industry innovation if the Uranium market predictions prove to be accurate.

However, these skills are dispersed and not structured for rapid deployment for identifying and accessing Uranium resources. Consideration would need to be given to the training and development of the next generation of researchers since there is no longer a tertiary institution offering nuclear engineering within Australia and because there is a critical shortage of graduates entering the exploration and mining industry in general.

Implications for greenhouse gas emission reductions

Life cycle of greenhouse gas emissions

The first term of reference, regarding the potential implications for global greenhouse gas emission reductions, revolves around the key question of whether the production of a unit of uranium produces lower greenhouse gas emissions than a unit of fossil fuel.

On a full fuel cycle basis nuclear power stations produce less than 40 kg CO_2/MWh compared to 760 kg CO_2/kWh from a state-of-the-art pulverised-fuel fired power station firing black coal at around 41% overall thermal efficiency. A calculation has shown that CO_2 emissions would increase by 1,930 million tonnes per annum if nuclear power stations were converted to coal. Current emissions from power stations in Australia are approximately 180 million tonnes per annum. This estimate is based on data from the Uranium Information Centre reporting that 2523 billion kWh of electricity were generated from nuclear sources in 2003.

Energy Futures Forum

CSIRO has established the Energy Transformed National Research Flagship Program with the goal of achieving cost effective reductions in greenhouse gas emissions from the energy sector. As part of this program, an Energy Futures Forum has been set up to bring together a broad spectrum of industry and community groups in a structured and highly sophisticated scenario planning exercise exploring potential futures of the Australian stationary energy and transport industries (see Appendix 1).

Running over an 18-month period, the Forum will develop key energy scenarios that will be modelled by purpose-built world-class techno-economic models to determine potential energy industry and technology pathways and highlight possible impacts to society, environment and the economy. The range of energy scenarios considered will include those addressing the potential for nuclear power in the mix.

Scenarios will be developed by industry and community forum participants only (assisted by a professional facilitator) – CSIRO and ABARE provide the modelling tools and analysis.

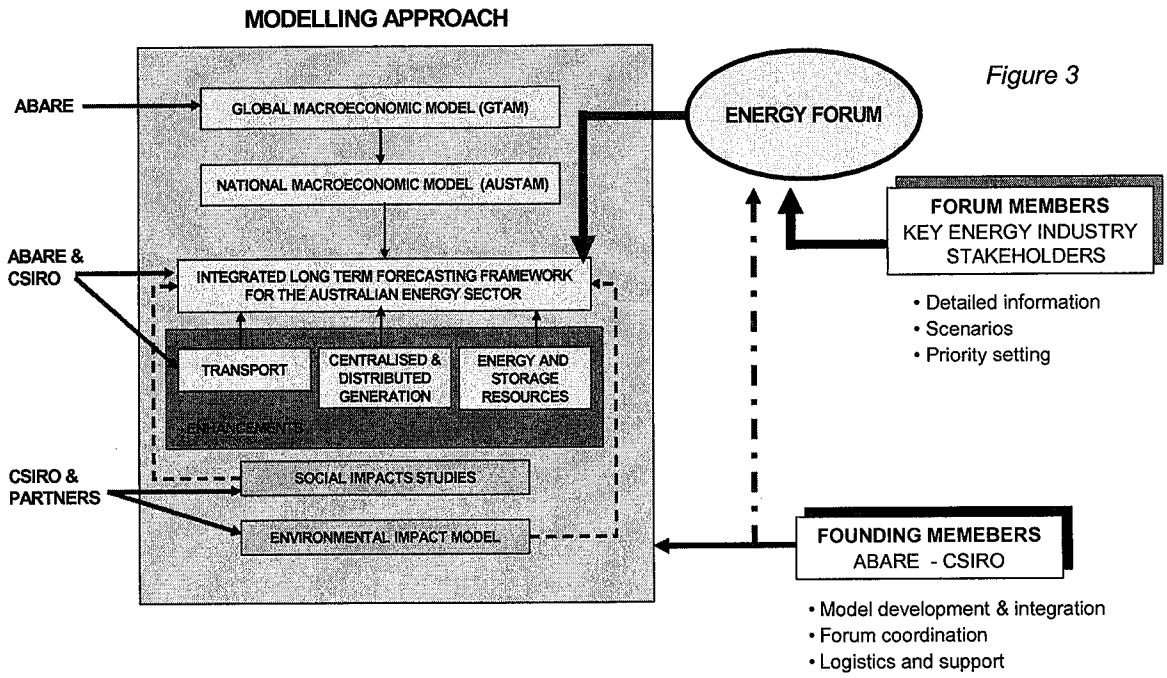


Figure 3

The Forum includes:

- Banks and Venture Capital Funds
- Community representatives
- Environmental groups
- Energy and Fuel producers
- Electricity generators
- Government
- Large energy users/Manufacturing
- Research providers (social, economic, technology)
- Transport

The outcomes of this study – due in 2006 – will form a highly credible basis for informing policy formulation and industry decision-making.

Conclusions

With almost half the known low-cost Uranium resources in the world, Australia has the potential to strengthen its market position.

If Australia could add value by sourcing new deposits of Uranium and by enabling greater levels of recovery from known deposits through innovative technology, it could position itself as the global leader in Uranium mining.

Australia's ability to increase the strategic value of its Uranium resources lies in the ability to deliver it efficiently to the market place. Australia could consider extending its technological operations significantly along the Uranium fuel chain.

To achieve this existing skills around Australia would need to be coordinated to establish a critical mass in support of industry innovation. Consideration would need to be given to the training and development of the next generation of researchers; there is no longer a tertiary institution offering nuclear engineering within Australia, and there is a critical shortage of graduates entering the exploration and mining industry in general.

Appendix 1

Energy Futures Forum Brochure

The Energy Futures Forum

Bringing together Australia's energy and transport stakeholders to identify plausible scenarios and their implications for the nation's energy future

In Australia and overseas, economic growth will continue to drive demand for low cost energy. At the same time, there is increasing global pressure to reduce greenhouse gas emissions threatening environmental sustainability, and the viability of this country's major energy industries.

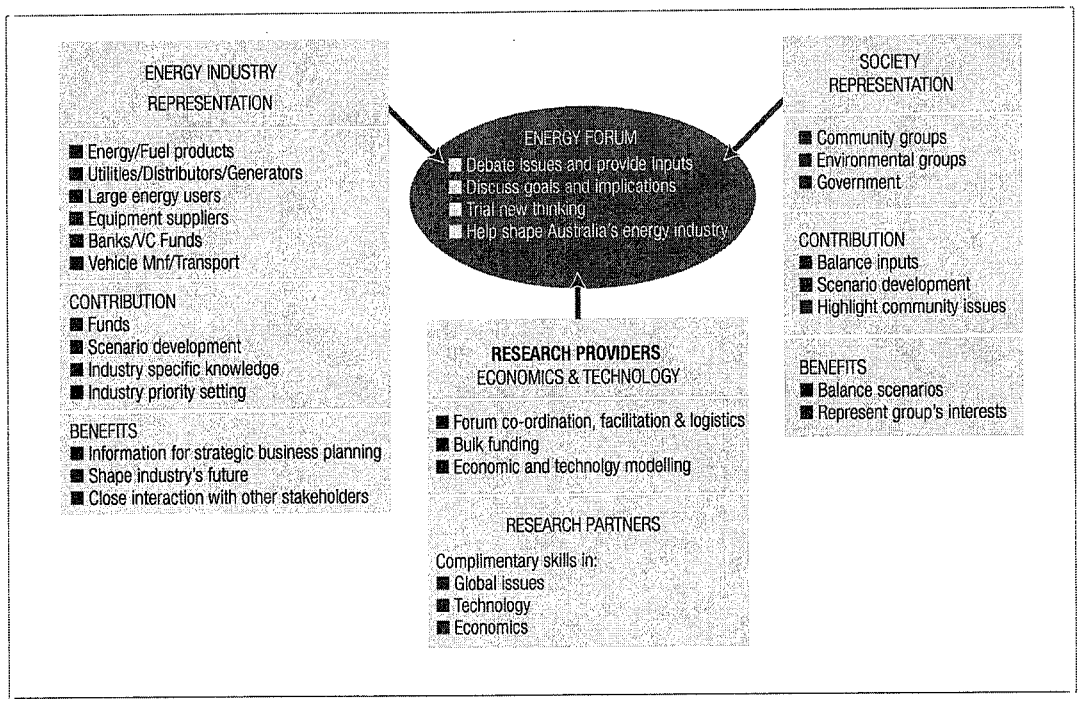
The challenge for Australia is to take advantage of our energy opportunity without compromising the natural environment. Now is a critical time for Australia, as many infrastructure decisions, some of which will have impacts which extend into the next few decades, will need to be considered to meet the twin drivers of emission reduction and growing energy demand.

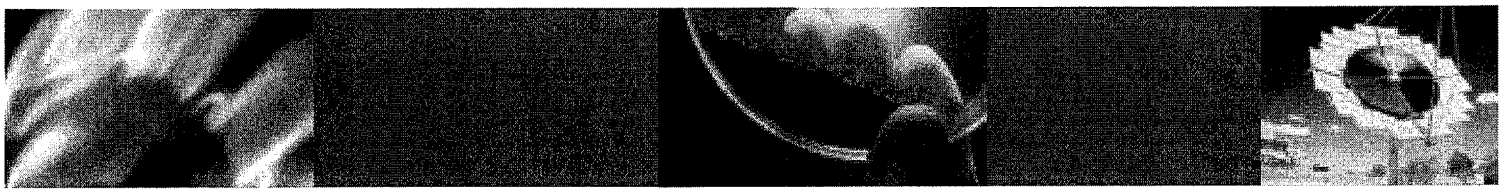
THE ENERGY FUTURES FORUM

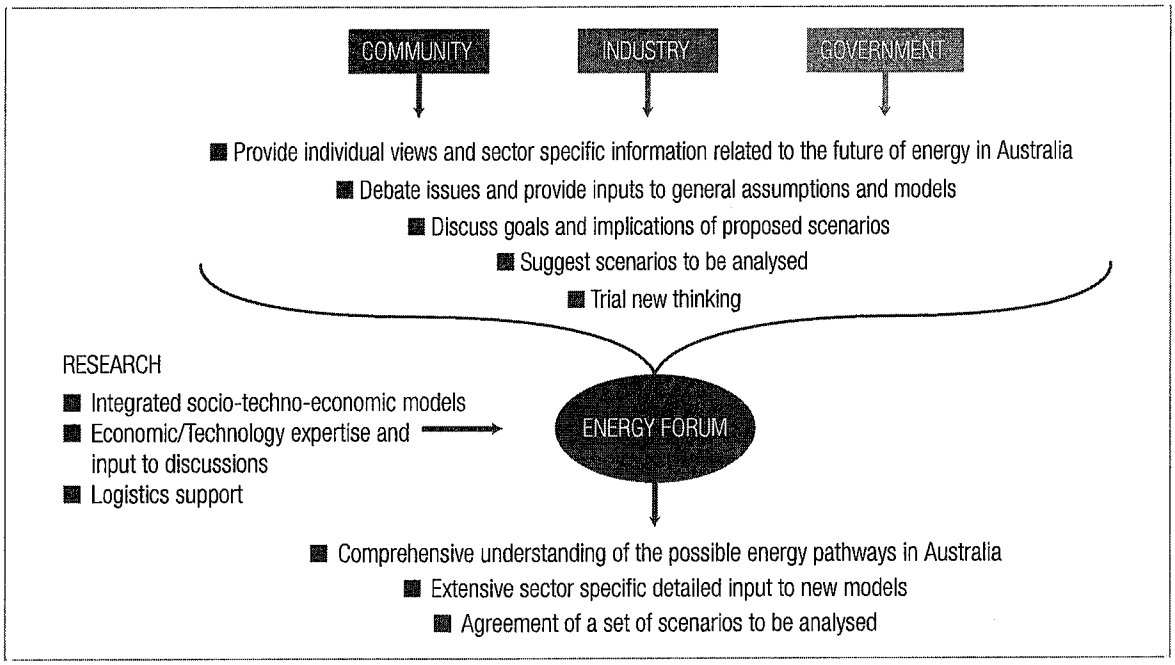
The Energy Futures Forum brings together a broad spectrum of industry and community groups in a structured scenario planning exercise exploring potential futures of the Australian Stationary Energy and Transport Industries.

The Energy Futures Forum is a sector wide initiative, running over an 18 month period, established to develop key energy scenarios that will be modelled by purpose-built world-class techno-economic models to determine potential energy industry and technology pathways and highlight potential impacts to society, environment and the economy.

This new approach to energy industry modelling integrates technology and economic models into one single, integrated analysis tool. The new models will incorporate ABARE's economic models, CSIRO's technology knowledge and other leading Australian and international sociological and environmental studies.







FORUM OBJECTIVES

The objectives of the Energy Futures Forum are to:

1. Promote constructive dialogue between a diverse range of stakeholders in the Australian energy industry on its long term future
2. Identify a range of plausible scenarios available to Australian society for future energy options by bringing together views from industry and the community, highlighting the key issues faced by the industry in a unique discussion exercise
3. Use improved, purpose-built integrated models featuring a linkage of economic, technology development and implementation, social attitudes and environmental modelling
4. Analyse, quantify and discuss the major social, environmental, economic and technology implications for each scenario
5. Provide information for different organisations to use to meet their needs, e.g.
   - Government to use in energy and environment policy development
   - NGO's to inform policy development
   - Businesses to inform investment strategies
   - CSIRO to use in the development of future Research programs

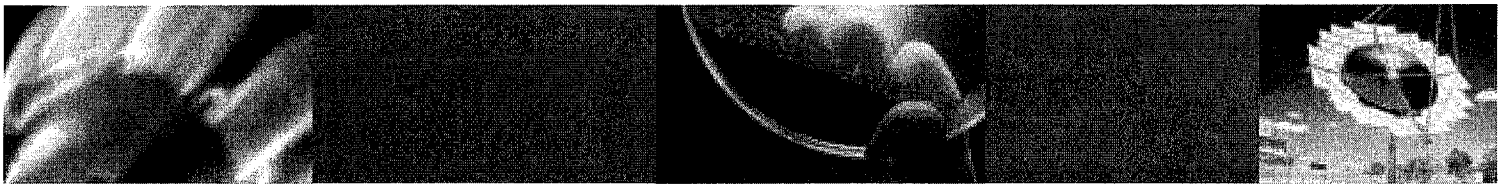
PARTICIPATION

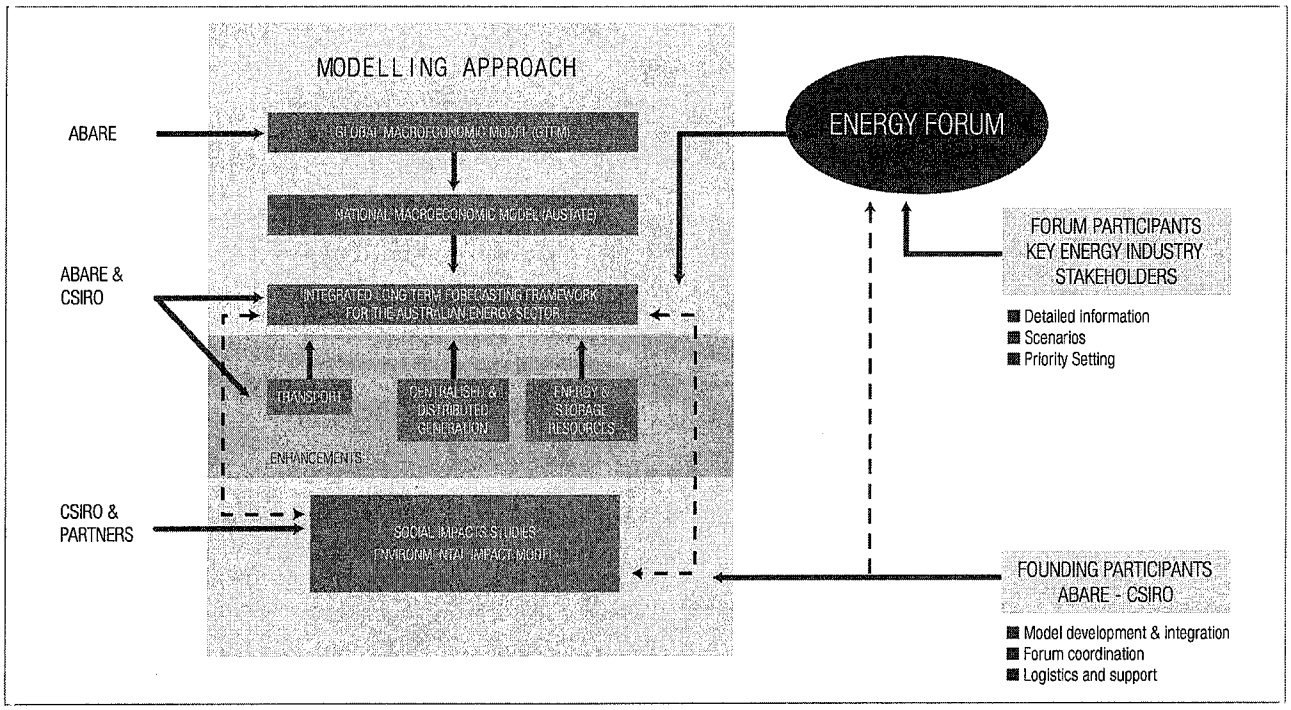
The Forum includes:

- Bank's/VC Funds
- Community representatives
- Environmental groups
- Energy/Fuel producers
- Electricity generators
- Government
- Large energy users/Manufacturing
- Research providers (social, economic, technology)
- Transport

Participants were selected by CSIRO to reflect a balanced representation of the key stakeholder groups.

Scenarios developed by the forum may be distributed to wider consultative groups for input and as part of social impact modelling. However, such distribution will be subject to confidentiality arrangements.





SCENARIO BUILDING & DISCUSSION

The first major objective of the forum is to develop a set of energy scenarios for Australia:

- Scenarios will be developed by industry and community forum participants only (assisted by a professional facilitator) – CSIRO and ABARE provide the modelling tools and analysis. Broader circulation or consultation of scenarios to wider industry groups may also be conducted.
- The final set of scenarios is reached partially through consensus and partially through voting rights that come with participation
- CSIRO and ABARE will not promote particular scenarios but will contribute with economic and technology advice where requested by forum participants

SCENARIO MODELLING

Scenarios developed by the forum will be modelled using state-of-the-art purpose-built models of the energy sector, national and global economy. Preliminary modelling results will be discussed with participants to refine and fine tune the process and assumptions going into the models.

Scenario modelling will take advantage of the ABARE – CSIRO combination to:

- Increase the detail and sophistication with which supply side energy technologies, energy resources and niche energy markets are represented
- Use information from work being conducted to understand social attitudes to energy and transport
- Include forum members' feedback

CURRENT PARTICIPANTS:

Alcoa World Alumina Australia

Australian Automobile Association

Australian Conservation Foundation

Australian Council of Social Service

BHP Billiton

Department of Industry Tourism and Resources

ENERGEX

Hydro Tasmania

Loy Yang Power

NSW electricity generators*

OneSteel

Orica

Origin Energy

Pacific Hydro

Public Interest Advocacy Centre

Rio Tinto

Stanwell Corporation

Westpac Banking Corporation

Woodside Energy

WWF Australia

Xstrata Coal

*Joint particpants Delta Electricity, Eraring Energy & Macquarie Generation

The current list of participants shown above is subject to periodic review by Forum Participants, CSIRO and ABARE.

COMMUNICATION OF FORUM GENERATED INFORMATION

It is intended that the information (excluding commercial-in-confidence data) will be made available to the public.

CONTACT DETAILS:

For more information on the Energy Futures Forum please contact:

Forum Spokesperson
John Wright
Director
Energy Transformed Flagship
Phone: 02 4960 6080
Email: John.Wright@CSIRO.au

www.csiro.au

CSIRO

Information contained in this brochure was current as of 25/2/2005 and may be subject to change.

Bringing together Australia's energy and transport stakeholders to determine plausible scenarios and their implications for the nation's energy future