



Australia's uranium (reissued 11 September 2009)

With the release of the draft Switkowski report 'Uranium mining, processing and nuclear energy—opportunities for Australia?' and the House of Representatives Standing Committee on Industry and Resources report 'Australia's uranium—greenhouse friendly fuel for an energy hungry world' the use of nuclear power to reduce greenhouse gas emissions has taken greater prominence in debate.¹

In this context, Australia's large resources of uranium—the feedstock of nuclear power—will become more important. In addition, the growing gap between supply of and demand for uranium is driving world prices higher, ultimately to the advantage of Australia's uranium miners.

This note examines the issues of Australia's uranium in the context of world supply and demand, shows why world prices are rising, and looks to the future of the uranium industry in the environmental debate over greenhouse gas emissions.

Uranium

Uranium is a naturally occurring radioactive element which is a mixture of several forms, or 'isotopes', of uranium.² Of these isotopes, uranium-235—referred to symbolically as ²³⁵U—is capable of sustaining a nuclear chain reaction. A chain reaction can be controlled to release large amounts of energy which can be used to generate heat.³ The heat energy released is used to generate steam which drives turbines which in turn generate electricity. Although other elements are also capable of sustaining chain reactions, uranium is the cheapest and most abundant.⁴ Hence ²³⁵U is of importance as a fuel in the nuclear reactors used to produce electricity in a number of countries worldwide.

Uranium—containing ²³⁵U—is extracted from naturally occurring uranium ores. These ores are processed using acid or alkaline leach technologies to recover uranium concentrates which are bright yellow in colour and referred to as 'yellowcake'.⁵ Yellowcake is then heated to about 700°C to produce a dark powder containing more than 98 per cent uranium oxide—U₃O₈—which is placed in 200-litre steel drums for export.⁶

²³⁵U is not sufficiently concentrated in uranium in its natural state for the uranium to be useful as a fuel. The natural occurrence of about 0.7 per cent ²³⁵U needs to be

increased—'enriched'—to around three per cent ²³⁵U.⁷ Uranium producers in Australia do not attempt this process which needs highly specialised and expensive equipment. This enrichment process is carried out overseas using Australian-exported uranium. Eventually the ²³⁵U-enriched uranium is used to manufacture fuel rods for nuclear power reactors in countries prepared to sign Australian nuclear safeguards agreements (for which see below).

Australia's uranium resources

Australia has the world's largest resources of low-cost uranium (recoverable at costs of less than US\$40 per kilogram of uranium), with approximately 36 per cent of world resources in this category. It has 27 per cent of the world's resources recoverable at less than US\$80 per kilogram of uranium and 23 per cent of the world's resources recoverable at less than US\$130 per kilogram of uranium.⁸

In tonnage terms, Australia has 701 000 tonnes of uranium resources recoverable at costs of less than US\$40 per kilogram of uranium; 714 000 tonnes of resources recoverable at costs of less than US\$80 per kilogram of uranium; and 747 000 tonnes of resources recoverable at costs of less than US\$130 per kilogram of uranium.⁹ In effect this means that Australian uranium resources are mostly able to be extracted at low cost—as the above figures show it has a mere 13 000 tonnes recoverable at between US\$40 and US\$80 per kilogram and 33 000 tonnes recoverable at between US\$80 and US\$130 per kilogram.¹⁰

This resource base, and the potential to develop new mines and increase uranium production, makes Australia significant in the world uranium market.

Demand for uranium

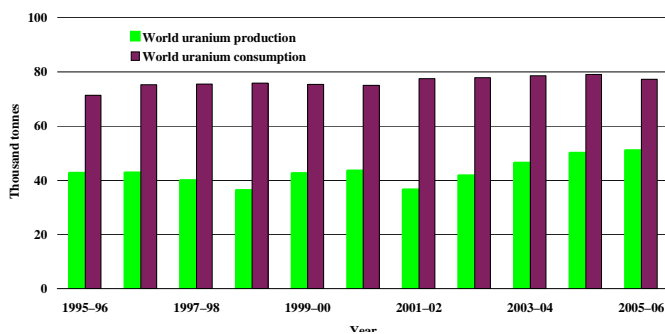
Demand for Australia's uranium is ultimately a function of installed nuclear electricity capacity in countries prepared to sign up to Australia's nuclear safeguards policy.

Worldwide there are currently 442 nuclear power plants in operation. Their total installed capacity is around 370 gigawatts electrical which is equivalent to about eight times the total installed capacity of all conventional electricity generation plants in Australia.¹¹ By the year 2030, it is expected that nuclear power reactors operating

worldwide will have an installed electricity generating capacity of between 414 and 679 gigawatts electrical.¹² Factors which influence this growth in nuclear generating capacity include economic and population growth, energy security, environmental considerations, and the relative cost of nuclear power generation.

For some time now, world requirements for uranium have exceeded world production, with a proportion of requirements being met from the conversion of highly enriched uranium from obsolete military warheads. Additional supplies are now also coming from uranium produced in the new states formed after the break up of the Soviet Union; these had not previously been provided to the world market.¹³

Graph 1: World uranium production and consumption 1995-96 to 2005-06

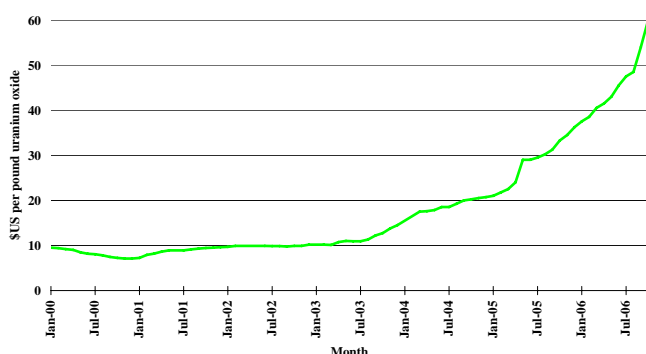


Graph 1 shows world production and consumption of uranium since 1995-96.¹⁴

Despite the obvious long-term imbalance and the consequent reduction in stockpiles, world uranium prices have not risen until the last few years. Low prices were due to the presence of a large world uranium stockpile and the uncertainty of the outcome of political decisions concerning the use of military stockpiles, the decommissioning of old warheads, and the use of uranium from the states of the former Soviet Union. Other factors included a low growth rate in world nuclear generating capacity and an expansion in global mine production.

Graph 2 shows monthly average world uranium spot prices since January 2000. Because of the dominance of the USA in the world uranium market, these prices are quoted as

Graph 2: Uranium prices January 2000 to October 2006



\$US per pound of U_3O_8 .¹⁵ Although Australia's uranium is sold under long-term contract rather than onto the spot market, these spot prices do give an indication of the state of the world uranium market in which future contracts will be written. It is clear from these data that there has been a large increase in uranium spot prices in the past few years. This increase in prices looks set to continue.¹⁶

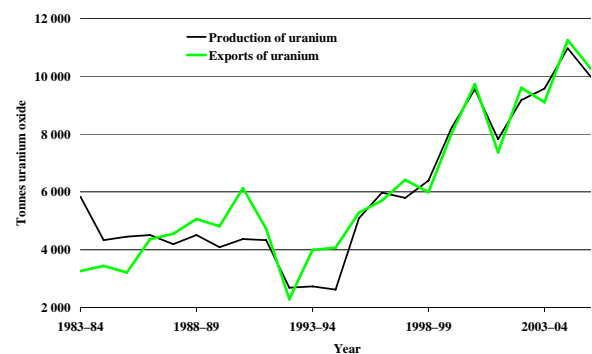
Australian production and exports

Production of uranium in Australia makes up about one-quarter of world production. Production is from three mines: Ranger in the Northern Territory, and Olympic Dam and Beverley in South Australia.¹⁷

Australian production and exports of uranium closely parallel one another—all Australian production is exported because there is no significant domestic demand.

Graph 3 shows that current production and exports are approaching 11 000 tonnes of uranium oxide per year.¹⁸ Figures for 2006-07 included in the graph are Australian Bureau of Agricultural and Resource Economics (ABARE) forecasts.¹⁹

Graph 3: Australian production and exports of uranium 1983-84 to 2006-07

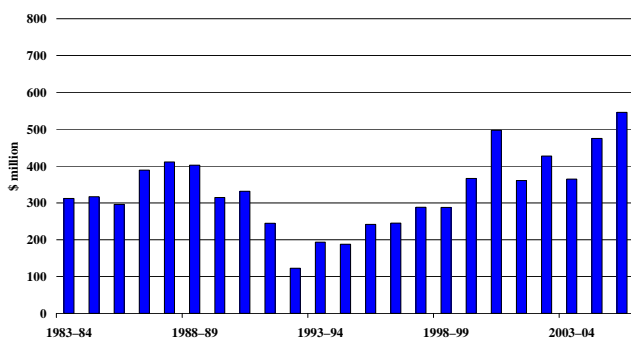


Uranium is an important export earner for Australia. In 2005-06, for example, Australia exported \$546 million worth of uranium. Graph 4 shows the value of Australian exports of uranium since 1983-84. In that period, exports have averaged around \$350 million per year but, from a low of \$123 million in 1992-93, exports have progressed to a forecast \$724 million for 2006-07.

Nuclear safeguards policy

Australia applies conditions to the export of uranium under its nuclear safeguards policy. This policy, which began in 1977, is intended to ensure that Australian uranium is not used for, or diverted to, nuclear weapons programs.²⁰ In practical terms, this is based primarily on the buyer being a signatory to the Nuclear Non-Proliferation Treaty.²¹ In addition, Australia requires buying countries to enter into a bilateral agreement, thereby further ensuring among other things that the uranium is covered by International Atomic Energy Agency safeguards throughout its life; that Australian uranium is only transferred to third parties with

Graph 4: Value of Australian uranium exports
1983–84 to 2006–07



Australian consent; and that the uranium is kept physically secure. Australia currently has 20 nuclear safeguards agreements which cover 36 countries plus Taiwan.²²

Compliance with Australia's nuclear safeguards policy is monitored by the Australian Safeguards and Non-Proliferation Office.²³

The future

The future of Australia's uranium industry will depend largely on global growth in nuclear generating capacity. Concerns about the environmental effects of greenhouse gas emissions from coal fired electricity generation and the uncertain price of oil will increase the importance of nuclear powered electricity in the future mix of energy sources. However, several factors may act to limit growth in nuclear generating capacity, these include: Australian and worldwide concerns about the environmental health dangers of mining and using uranium, the need to store nuclear fission products for very long periods of time, and the issues concerned with the de-commissioning of nuclear electricity reactors at the end of their useful life.²⁴

Greg Baker
Statistics and Mapping Section
Parliamentary Library

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1. Review of uranium mining, processing and nuclear energy in Australia, *Uranium mining, processing and nuclear energy—opportunities for Australia?*, Department of Prime Minister and Cabinet, Barton ACT, 2006; and House of Representatives Standing

Committee on Industry and Resources, 'Australia's uranium—greenhouse friendly fuel for an energy hungry world', Canberra, November 2006.

2. In simple terms, an element is a substance which cannot be changed into another substance by ordinary chemical processes. Iron, for example, is an element. A radioactive element is an element that has an unstable atomic nucleus—this sort of element spontaneously and randomly alters the state of its atomic nucleus emitting sub-atomic particles in the process. This process is called radioactivity. Isotopes are atoms of the same element but with different atomic nuclei.
3. A uranium atom when struck by a sub-atomic particle called a neutron, splits yielding two smaller atoms and several more neutrons giving off heat in the process. If the neutrons so released strike other uranium atoms and they in turn produce neutrons striking yet more uranium atoms, a chain reaction can result. This process is able to be controlled and the heat harnessed to produce the steam needed to drive steam turbines. See Ian Clark and Barry Cook, 'Uranium', *Introduction to Australia's Minerals*, vol. 5, Uranium Information Centre, 2000, p. 2.
4. The use of the element thorium as a nuclear fuel is also considered to have long-term potential. Uranium Information Centre, 'Thorium', *Briefing Paper*, no. 67, November 2006, <http://www.uic.com.au/nip67.htm>, accessed on 8 December 2006.
5. A description of these leach technologies can be found in Paul Kay, 'Beyond the three mines—in situ uranium leaching proposals in South Australia', Department of the Parliamentary Library, *Research Paper*, no. 12, 1997–98; and Uranium Information Centre, 'In situ leach (ISL) mining of uranium', *Briefing Paper*, no. 40, UIC, November 2006, <http://www.uic.com.au/nip40.htm>, accessed on 14 December 2006.
6. Ian Clark and Barry Cook, op. cit., p. 11. Also see endnote 15 for the amount of uranium in U₃O₈.
7. *ibid.*, p. 12.
8. OECD Nuclear Energy Agency and International Atomic Energy Agency, *Uranium 2005: resources, production and demand*, NEA and IAEA, Paris and Vienna, 2006, p. 15. The figures given do not include inferred resources, which are resources which are believed to occur based on geological evidence. If these inferred amounts are included Australia has 38 per cent of the world's identified resources recoverable at less than US\$40 per kilogram. Note that the amount given for less than US\$80 per kilogram includes the amount for less than US\$40 per kilogram and the amount for less than US\$130 per kilogram includes the amounts for less than US\$80 per kilogram and less than US\$40 per kilogram.
9. *ibid.* Although these amounts appear small, it should be noted that one kilogram of enriched uranium ultimately yields about 360 gigawatt hours of electricity. Total annual electricity generation in Australia would need less than one tonne of enriched

- uranium which is less than five tonnes of uranium from the mine. Uranium Information Centre, 'The nuclear fuel cycle', <http://www.uic.com.au/nfc.htm>, 2006, accessed on 18 December 2006 and Electricity Supply Association of Australia, 'Electricity Gas Australia 2006', ESAA, 2006, Table 2.5, pp. 18–19.
10. House of Representatives Standing Committee on Industry and Resources, *Australia's uranium—greenhouse friendly fuel for an energy hungry world*, Canberra, November 2006, p. 81, <http://www.aph.gov.au/house/committee/isr/uranium/report/fullreport.pdf>, accessed on 23 March 2007.
 11. International Atomic Energy Agency, *Power Reactor Information System* at <http://www.iaea.org/programmes/a2/index.html>, accessed on 27 November 2006. In 2004–05, Australia's grid-connected installed generation capacity was 45 gigawatts. Energy Supply Association of Australia, *Annual review 2005–2006*, ESAA, Melbourne, 2006, p. 8. Note that a megawatt is one million watts and a gigawatt is one thousand megawatts. One thousand watts (one kilowatt) is the amount needed to power a standard one-bar radiator.
 12. International Atomic Energy Agency, *Energy, electricity and nuclear power estimates for the period up to 2030*, July 2006 edition, IAEA, Vienna, 2006, p. 17.
 13. Uranium is now supplied to the world market from Kazakhstan, the Russian Federation, and Uzbekistan. OECD Nuclear Energy Agency and International Atomic Energy Agency, *Uranium 2005: resources, production and demand*, NEA and IAEA, Paris and Vienna, 2006, p. 28.
 14. Graph data from Australian Bureau of Agricultural and Resource Economics (ABARE), *Australian commodities*, various issues.
 15. One pound (0.45 kilogrammes) of U₃O₈ contains 0.85 pounds (0.39 kilograms) of uranium.
 16. Graph data from ABARE, *Australian commodity statistics 2006*, p. 337. For a discussion of future trends in the uranium spot price see Australian Bureau of Agricultural and Resource Economics, *Australian commodities*, vol. 13, no. 1, March quarter 2006, p. 102; and Review of uranium mining, processing and nuclear energy in Australia, op. cit., p. 23.
 17. A fourth mine, Honeymoon in South Australia, is likely to begin production in 2008. 'Approval to mine', *Canberra Times*, 30 September 2006, p. 4.
 18. Graph data from ABARE, *Australian commodities*, several issues, and ABARE, *Australian commodity statistics 2006*, p. 334.
 19. Australian Bureau of Agricultural and Resource Economics, *Australian commodities*, December quarter 2006, pp. 751 and 758.
 20. The Minister for Foreign Affairs, Alexander Downer, re-iterated government support for this policy as recently as March 2006: Australian Broadcasting Corporation, *Insiders*, 12 March 2006, transcript at http://www.foreignminister.gov.au/transcripts/2006/060312_insiders_programme.html, accessed on 6 December 2006.
 21. The full text of the Nuclear Non-Proliferation Treaty is at <http://www.iaea.org/Publications/Documents/Infcircs/Others/infcirc140.pdf>, accessed on 18 December 2006.
 22. Australian Safeguards and Non-Proliferation Office, *Annual Report 2005–06*, 2006, p. 27.
 23. The Australian Safeguards and Non-proliferation Office is at <http://www.asno.dfat.gov.au>.
 24. Environmental concerns have led to the closure of nuclear electricity reactors in several countries. Sweden's Barsebäck 1 power station was closed in 1999 following an earlier decision to close that country's nuclear industry; further closures have been put on hold. In Germany, many nuclear reactors were closed in the late 1980s and early 1990s and no new reactors are planned. See for example Nick Hordern, 'Red faces in Europe over greenhouse gas targets', *Australian Financial Review*, 24 February 2000 and the International Atomic Energy Agency's Power Reactor Information System at <http://www.iaea.org/programmes/a2/index.html>.