# Submission to Uranium Mining, Processing and Nuclear Energy Review Secretariat

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## Introduction

In making this submission, I wish to point out that the Terms of Reference of this Review are too narrow to address the important issues of energy and greenhouse policy facing Australia, which include:

- greenhouse targets and timetables;
- assessment of a wide range of technologies capable of reducing greenhouse gas emissions, including efficient energy use, renewable energy, fuel substitution and fossil fuels with $CO_2$ capture and sequestration;
- policies and strategies to reduce $CO_2$ emissions, including economic, regulatory, institutional and informational/educational instruments.

Therefore, the recommendations of this review cannot validly compare nuclear energy with other energy sources or make any recommendations on energy policy in general.

I also have concerns about the composition of the review committee, which does not have a single critic of the nuclear industry and is composed of people with backgrounds that will inevitably influence them to support the nuclear industry, by selecting evidence that favours nuclear industry and rejecting evidence that does not favour the industry. This comment is not intended to reflect upon the expertise or integrity of individual committee members. It merely points out there is a large body of scholarship from the sociology of science and technology showing that 'experts' are human and are influenced in their decisions, unconsciously or otherwise, by their educational and professional backgrounds. The criticism is of the process of appointing the committee, not the members of the committee.

My expertise is in energy policy, efficient energy use technologies and processes, renewable energy technologies, and economics and environmental impacts of various energy sources, including nuclear power. I have been a researcher and tertiary-level teacher in these areas for more than 25 years. I have published nearly 100 scholarly publications, including several books. From 1996 to 2001 I was Professor of Environmental Science at University of Technology, Sydney.

Because of limited time, I will not attempt to address all the terms of reference. In this submission each term of reference is listed in Arial (sans cerif) font and then my response (if any) is given in Times Roman (cerif) font.

## Economic issues

### (a) The capacity for Australia to increase uranium mining and exports in response to growing global demand.

No comment.

### (b) The potential for establishing other steps in the nuclear fuel cycle in Australia, such as fuel enrichment, fabrication and reprocessing, along with the costs and benefits associated with each step.

***Uranium enrichment***

Despite the rhetoric about 'adding value', there is no potential for establishing a uranium enrichment industry in Australia based on conventional technology, i.e. gas centrifuge. This is because there is currently a global overcapacity of this technology and the USA is building a new centrifuge enrichment plant. Australia could never compete in such a market. I have not attempted to document this because even a brief search of nuclear industry sources on the Web confirms this.

A new enrichment technology, laser enrichment, by a company called Silex, has been under way in secret at the ANSTO facility at Lucas Heights[1]. The state of development of this technology and its economics are unknown to the public. This technology may offer enhanced risks of proliferation of nuclear weapons.

***Reprocessing of spent fuel***

This involves dangerous, expensive processes for remote handling of high-level nuclear spent fuel. It is questionable whether this is a genuinely commercial, profitable industry, without subsidy, anywhere in the world. Three 'commercial' reprocessing plants have been built and closed down in the USA. The UK's facility at Sellafield (formerly Windscale) has been closed for 16 months as the result of the escape of a large quantity of high-level liquid nuclear waste. An earlier accident, when the plant was called Windscale, released quite large quantities of radioactive materials into the environment. The only 'commercial' reprocessing plant remaining is La Hague in France -- independent data on its operation, safety and economics are not publicly available.

Therefore, it would be very risky, both economically and environmentally, for Australia to become involved in this technology.

(c) The extent and circumstances in which nuclear energy could in the longer term be economically competitive in Australia with other existing electricity generation technologies, including any implications this would have for the national electricity market.

Anyone can speculate about the long-term economics of nuclear power. However, based on current economics and near-term estimates by experts who are independent of the nuclear industry, the economic potential does not appear favorable.

Even the analyses of some experts from the nuclear industry, or agencies representing that industry, present reports that are unfavourable, once the reader goes behind the optimistic executive summaries that appear to be designed to win over the media. An example is the report to ANSTO by leading nuclear industry figure, John Gittus, claiming that a non-existent nuclear power station, AP1000, would be competitive with coal power in eastern Australia, *under certain conditions*[2].

The Gittus report's conditions are indicated in two alternative scenarios. One involves substantial government subsidies on the capital and operating costs of the proposed power station. The other involves 'no subsidy', according to Gittus, just a massive government guaranteed, unsecured

> "insured loan, which would be repaid to Government, together with a retrospective premium, out of revenues from the station once it began to generate electricity".

But, what if the untried nuclear power station proves to be more expensive to build and operate than the paper study estimates? That has always been the case with nuclear power in the past. What if the earnings from electricity sales prove to be insufficient to repay the additional costs and the loans? The Gittus report is vague on such details, suggesting that the government (i.e. the taxpayer) would share the risk. If so, this is a subsidy dressed up as a loan and neither of Gittus's scenarios is anywhere near being economically competitive with conventional coal power.

If this proposal is a good deal for the lender, why is it necessary for the government to lend anything? Surely, private financial institutions would be queuing up? Though it's strange that no private investors have funded a new nuclear power station in the USA for over a quarter century, despite massive subsidies to the industry estimated at about US$80 billion in total[3].

A report to the UK Sustainable Development Commission points out difficulties of obtaining objective data on the economics of the current generation of nuclear power stations[4]. The following concerns expressed in that report apply equally well to Australia:

> "There are few sources of data on the costs of future nuclear power that relate directly to UK circumstances… The problematic category is capital costs, where there is no recent European or North American experience. Examination of the limited number of published capital cost estimates that apply directly to the UK shows that all appear to derive from studies originally designed to apply to other countries *and from vendors of reactor systems*." (my italics)

Claims by the industry that nuclear energy is cheap are often unverifiable bottom-line results or 'justified' by analyses with hidden assumptions that are highly favourable to nuclear power. For example:

- Because nuclear energy has a high capital cost and low operating cost, choosing an unrealistically low interest or discount rate can make nuclear energy look much less expensive than it really is.

- Another means of disguising the high annualised capital cost of nuclear energy is to chose certain accounting methods (such as one based on historical costs) that shrink the capital cost component. This device was used in the UK in the years before electricity industry restructuring[5].

- Ignoring the huge subsidies from government to nuclear energy also makes the technology look less expensive. Varying from country to country, these subsidies include R & D, uranium enrichment, decommissioning and limited liabilities for accidents. In the USA they are estimated to have accumulated over the 50-year period 1948 to 1998 to about US$74 billion[6] or around US$80 billion in 2006 currency. In the UK, the Nuclear Decommissioning Authority has estimated that the cost of decommissioning existing nuclear power stations to be about £70 billion, recently increased to £90 billion.

- Making over-optimistic assumptions about operational performance as measured by capacity factor[7] of the nuclear power station is another method. Nuclear proponents often choose as typical the year with the highest capacity factor, instead of averaging the capacity factor over the lifetime of the station.

- When comparing coal and nuclear as potential competitors for base-load operation, the nuclear industry often assumes that coal is operated as intermediate-load while nuclear is base-load, thus assigning a low capacity factor to coal. This is obvious inappropriate when considering different energy technologies as competitors for base-load power.

When the UK electricity industry was privatised, the British Government had to impose a Fossil Fuel Levy to subsidise nuclear electricity[8]. In the 1990s the annual subsidy reached £1.2 billion per year, equivalent to a subsidy of about 3 p/kWh or AUS 6 c/kWh on each unit of nuclear electricity generated, making the total generation cost of nuclear power about 6 p/kWh or AUS 12 c/kWh. (For comparison, the generation cost of coal power in eastern Australia is less than 4 c/kWh.) The subsidy alone to nuclear power in the UK is almost as much as the full cost of on-shore wind power in the UK, currently about 4 p/kWh. The decommissioning cost (see above) must be added to this. A full-size nuclear power station (1000 megawatts or more) has never been decommissioned anywhere in the world, costs could turn out to be even higher than estimated.

The last British nuclear power station to be built in the UK, Sizewell B, ended up with a capital cost of £2500/kW in 2005 British currency[9] (A$5000/kW). This extreme case demonstrates the financial risks involved. As recently as 2003, the British White Paper on Energy stated that "the current economics of nuclear power make it an unattractive option for new generating capacity".[10]

In the USA, there has not been a new nuclear power station built since the 1970s, despite massive subsidies, estimate as accumulating to about US$80 billion in today's currency. A pro-nuclear study, *The Future of Nuclear Power,* by an expert group from the Massachusetts Institute of Technology (MIT), ignored much of past US experience and made several optimistic assumptions about future capital and operating costs[11]. With a basic capital cost assumed to be US$2000/kW, a capacity factor of 85% and a lifetime of 40 years, it found the estimated cost of electricity from a hypothetical new nuclear power station to be US 6.7 c/kWh (about 9 c/kWh Aust.), increasing to US 7.5 c/kWh (10 c/kWh Aust.) for a capacity factor of 75%. Although the report stated that financing was done under market conditions, the interest rate chosen to repay the debt was surprisingly low at 8% nominal or 5% real, giving an advantage to nuclear power in comparison with fossil fuels.

For comparison, wind power is currently being generated at very good sites in the USA for US 4.5-5.5 c/kW. In Australia, it seems unlikely that nuclear power could be generated for less than 9-10 c/kWh (Aust.). Wind power at very good sites in Australia is currently being generated at 7.5-8.5 c/kWh (Aust.).

The only new 'commercial' nuclear power station under construction in a western country is currently taking shape in Finland. The nuclear industry claims that this demonstrates that nuclear energy is competitive in under market conditions. But the power station is being built by a consortium, that includes 40% share by the government of Finland, which will sell its electricity to its own members. Thus the consortium avoids conditions of a competitive market and so has obtained finance at interest rates far below market rates. The European Commission is currently considering a complaint about this anti-competitive practice.

On the global scene, consider the following frank summary of the 1998 electricity generating cost study that was published jointly by the International Energy Agency and the OECD Nuclear Energy Agency, both widely regarded as pro-nuclear. The raw data were supplied by the nuclear industries in the countries surveyed, so they are hardly likely to be biased against nuclear energy. The summary was presented by Dr Fatih Birol, the Chief Economist and Head of the Economic Analysis Division, International Energy Agency (IEA), at an Annual International Forum of the Uranium Institute.

> "The results confirm the current cost advantage of fossil-fuelled power generation… Clearly, under BAU [business-as-usual] assumptions the contribution of nuclear power over the next two decades will be limited."[12]

With a realistic discount rate of 10% real p.a., there were no countries out of 18 studied where nuclear energy was cheaper than either coal or gas. However, when an unrealistically low 5% real discount rate was chosen, nuclear energy was claimed to be the cheapest in 5 out of 18 countries[13]. Even the results for a 5% discount rate are likely to be over optimistic, because the data are supplied to the OECD by the nuclear industry itself and are not open to objective verification.

The harsh reality is that, at market discount rates for power stations of around 10% real, nuclear electricity is uneconomic almost everywhere in the world. It is at least double the cost of coal power in the USA and UK, and would be nearly 3 times the cost of (dirty) coal power in eastern Australia.

Even countries that do not have electricity markets have reservations about nuclear power.

China's target is for renewable energy (mostly wind power) to contribute 12% (recently increased to 15%) of electricity and nuclear only 4% by 2020.

The nuclear industry's solution to these economic realities has been to produce a series of reports on the economics of a 'new generation' of nuclear power stations that only exists on paper at present. In theory such reactors would be slightly cheaper and possibly slightly safer than existing models. But, the history of the nuclear industry's predictions shows that it has always been over-optimistic about future costs.

Nuclear power has severe adverse environmental, health and social impacts. Both offer big financial risks to investors. That's why the Gittus report requests that the government either pay a direct subsidy or take on much of the financial risk, which is an indirect subsidy. It is essential that the Australian community does not permit the government (i.e. the tax-payer) to take on the financial risk of building new nuclear power stations (or new dirty coal-fired power stations, for that matter).

***If the nuclear industry truly believes that nuclear electricity is economically competitive, let it take on the full financial risk.***

### (d) The current state of nuclear energy research and development in Australia and the capacity for Australia to make a significantly greater contribution to international nuclear science.

No comment.

## Environment issues

### (a) The extent to which nuclear energy will make a contribution to the reduction of global greenhouse gas emissions.

The nuclear industry has disseminated widely the false notion that nuclear energy emits no greenhouse gas emissions. The truth is that every step (except reactor operation) in the long chain of processes that makes up the nuclear fuel 'cycle' burns fossil fuels and hence emits carbon dioxide ($CO_2$). The emitting steps are uranium mining, milling fuel fabrication, uranium enrichment, construction and decommissioning of the reactor, and waste management.

Over the past 20 years there have been several calculations of $CO_2$ emissions from the nuclear fuel cycle. The most detailed comes from Van Leeuwen and Smith (VLS) (2005)[14]. VLS find that the $CO_2$ emissions from the nuclear fuel cycle are relatively small *when high-grade uranium ore* (comprising 0.1% or more yellowcake) is used. But there are very limited reserves of high-grade uranium in the world – most are in Australia and Canada. As these are used up over the next several decades, *low-grade uranium ore* (comprising 0.01% or less yellowcake) will have to be used. This means that to obtain 1 kg of yellowcake, at least 10 tonnes of ore will have to be mined and milled, using fossil fuels and emitting substantial quantities of $CO_2$. Contrary to the claims of the nuclear industry, VLS find that total $CO_2$ emissions from the nuclear fuel chain based on low-grade uranium ore are comparable in magnitude with emissions from a gas-fired power station.

In response, the nuclear industry cites a report by Swedish utility, Vattenfall, which only considers a single power station and obtains lower emissions than VLS in the case of high-grade uranium ore and apparently doesn't address low-grade uranium ore at all. This report has not been published and is not available on the Internet – only a summary[15], that does not reveal most of the assumptions or results, is available. It is very poor science to cite a report that is unavailable to the public.

Very recently Martin Sevior has presented data from a few specific uranium mines suggesting that the energy inputs to uranium mining may be lower nowadays than calculated by VLS based on 1970s data. It will take some time to compare the assumptions and data in the two studies. Meanwhile, VLS's order-of-magnitude result stands: that if you have to mine and mill 10 times as much ore to obtain 1 kg of uranium, you will have to use *at least* 10 times as much energy and (in Australia) will emit at least 10 times as much $CO_2$.

In summary, nuclear power, based on existing technologies, is a dead-end side-alley on the pathway to reducing $CO_2$ emissions.

### (b) The extent to which nuclear energy could contribute to the mix of emerging energy technologies in Australia.

It all depends on the magnitude of the subsidy. Clearly even a cumulative subsidy of US$80 billion was not sufficient to get a single new nuclear power station built in the USA since the 1970s. Now the Bush Administration is offering even greater subsidies for a new generation nuclear power station, so no doubt one will be built within the next decade. However, Australia is has a comparatively small economy and cannot afford to waste its citizens' money on such white elephants.

A more relevant issue is the rate at which nuclear energy could contribute to the rapid reduction of Australia's $CO_2$ emissions, assuming that more high-grade uranium is found. Nuclear power stations have long planning and construction periods (8-10 years or more). For comparison, most of the improvements in efficiency of energy use and several of the renewable energy alternatives have very short construction and implementation periods: e.g. substantial measures for efficient energy use can be installed within a few weeks or months at most; large wind farms can be planned, approved and installed in less than one year; and small bioenergy plants in less than two years.

## Health, safety and proliferation issues

### (a) The potential of 'next generation' nuclear energy technologies to meet safety, waste and proliferation concerns.

‘Next generation’ entails much speculation. The existing generation of nuclear power stations is neither fail-safe with respect to melt-down nor proliferation/terrorist proof, so there is huge potential for improvement. The big questions are whether the nuclear industry will invest in attempting to making nuclear power fail-safe, proliferation-proof and terrorist-proof, without massive subsidies from government (i.e. tax-payers) and whether anyone be prepared to pay for the costs of electricity from a really safe generation of nuclear power stations (assuming that this is technologically feasible), when less expensive, genuinely safe, renewable energy technologies are available now.

Australian decision-makers would be foolish and irresponsible to attempt to fund a new generation of nuclear power stations, e.g. by ordering an early model. This should be left to the very rich countries, USA and EU.

## (b) The waste processing and storage issues associated with nuclear energy and current world’s best practice.

I only offer the brief comment that the world’s richest country, USA, has so far failed to establish a long-term, environmentally secure, high-level waste dump. In the USA there is a political scandal about the Yucca Mountain waste dump and doubt about when or even whether it will ever open. Even if it does, its capacity is insufficient for even the US’s requirements. Australia would be unwise to attempt to build a waste dump that the US has so far failed to do properly.

## (c) The security implications relating to nuclear energy.

This includes both the risks of nuclear proliferation and terrorism.

As Richard Broinowski's book, *Fact or Fission*, documents, since World War II there has been a strong behind-the-scenes lobby for Australia to develop nuclear weapons. In the past, the main impediment was US policy. Now there are indications that US policy may have changed and it may be willing to turn a blind eye to Australian moves towards nuclear weapons from uranium enrichment and/or reprocessing of spent fuel.

One indication is that the US Government is undermining the Nuclear Non-Proliferation Treaty (NPT) by permitting the sale of its uranium to non-signatory, India, and the Australian Government is also undermining the NPT, with the connivance of the US Government, by selling uranium via the USA to Taiwan. It appears that the current US government wants to replace international nuclear weapons control (such as it is) under the NPT and IAEA by a proposed US-controlled scheme, inappropriately named Global Nuclear Energy Partnership (GNEP) [16]. While the NPT is far from adequate, it is better than nothing or unilateral USA control under GNEP. There seems to be no good reason for trusting the present or future Australian Governments to abstain from the former policies to develop nuclear weapons.

By selling uranium to China for nuclear power, Australia is enabling China to divert some of its uranium from nuclear power to nuclear weapons. There is no way of controlling this under the NPT or IAEA Safeguards.

It should be obvious that, by increasing its involvement in the nuclear fuel chain, Australia would be offering more prime targets to terrorists.

(d) The health and safety implications relating to nuclear energy.

No comment.

## Endnotes


[1] http://sites.greenpeace.org.au/frontpage/pdf/silex_report.pdf

[2] see www.ansto.gov.au/

[3] Public Citizen, Energy bill: billions more in taxpayer handouts to the failed nuclear industry. www.citizen.org/documents/NukeSubsidies.pdf

[4] MacKerron G et al. 2006, *Economics of Nuclear Power.* A report to the Sustainable Development Commission. Paper 4 of series, The role of nuclear power in a low carbon economy. www.sd-commission.org.uk/publications.php?id=339

[5] Jeffrey, JW 1980, The real cost of nuclear power in the UK. *Energy Policy* 8(4):344-6; Jeffrey, JW 1982, The real cost of nuclear electricity in the UK. *Energy Policy* 10(2):76-100; House of Commons select Committee on Energy 1981, *The Government's Statement on the New Nuclear Power Programme,* HC114-1, HMSO, London.

[6] Public Citizen, *op. cit*.

[7] Capacity factor is average power output divided by rated power, expressed as a percentage.

[8] Mitchell C 2000, The England and Wales fossil fuel obligation: history and lessons. *Ann. Rev. Energy Environ.* 25, 285-311, Table 4.

[9] Performance and Innovation Unit (PIU), 2002. *Working Paper on the Economics of Nuclear Power*. The Energy Review, Cabinet Office, Table 1, p.6.

[10] Department of Trade and Industry 2003, *Our Energy Future: Creating a low carbon economy*. Section 4.68. www.dti.gov.uk/files/file10719.pdf.

[11] Ansolabehere, S et al. (2003), *The Future of Nuclear Power*: An interdisciplinary MIT study. http://web.mit.edu/nuclearpower/.

[12] Birol F 1999, *Nuclear power in the world energy outlook*, Uranium Institute, 24th Annual International Forum, 1999, www.world-nuclear.org/sym/1999/birol.htm

[13] NEA/IEA 1998, *Projected costs of generating electricity*, Update 1998, Nuclear Energy Agency/International Energy Agency/OECD, Paris.

[14] www.stormsmith.nl

[15] www.environdec.com/reg/e_epd21.pdf

[16] www.gnep.gov