TOO HOT TO HANDLE? URANIUM AND NUCLEAR POWER IN AUSTRALIA'S ENERGY MIX

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Australia possesses 38% of the world's identified low-cost uranium reserves. As a result of increasing energy demands, rising energy prices and the fact that nuclear energy delivers lower greenhouse gas emission energy than fossil fuels, there is a renewed interest in this resource. On 28 April 2007, both the federal Coalition government and the opposition Australian Labor Party adopted new policies on uranium mining and nuclear energy in Australia. This article discusses the evolution of these policies and the role of uranium and nuclear power in Australia's energy mix.

1. INTRODUCTION

> Promoting nuclear power as the solution to climate change is like advocating smoking to cure obesity. That is, taking up the nuclear option will make it much more difficult to move to the sort of sustainable, ecologically healthy future that should be our goal.[1]
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> I am a Green and I entreat my friends in the movement to drop their wrongheaded objection to nuclear energy. Even if they were right about its dangers, and they are not, its worldwide use as our main source of energy would pose an insignificant threat compared with the dangers of intolerable and lethal heat waves and sea levels rising to drown every coastal city of the world. We have no time to experiment with visionary energy sources; civilisation is in imminent danger and has to use nuclear - the one safe, available, energy source - now or suffer the pain soon to be inflicted by our outraged planet.[2]

The legitimacy of mining Australia's uranium and contributing to the nuclear fuel cycle has been the subject of intense debate for many years. That only three uranium mines are in production in the country on the planet most richly endowed with this resource stands as a testament to this controversy.

Reignited by a confluence of global factors, there is new heat in this debate. Global demand for energy is increasing, with world energy needs forecast to more than double by 2030.[3] In the face of dwindling oil supplies, energy prices are on the rise and uranium prices are no exception. Most significantly, and despite the environmental issues posed by uranium mining and nuclear waste, nuclear energy has found new credibility as a "clean fuel", a potential energy alternative to carbon dioxide (CO_2) emitting fossil fuels.

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1 Professor Ian Lowe, "Reaction Time: Climate Change and the Nuclear Option" (2007) 27 *Quarterly Essay* 1 at 19.

2 Sir James Lovelock, "Nuclear Power is the Only Green Solution" (24 May 2004) *The Independent*, available at: http://www.ecolo.org/media/articles/articles.in.english/love-indep-24-05-04.htm.

3 Report of the Uranium Industry Framework Steering Group, *Uranium Industry Framework* (Canberra: Commonwealth of Australia, 2006) at 13 [hereinafter UIF].

On 28 April 2007, the current federal government adopted a new uranium strategy designed to increase uranium exports and prepare for the possible expansion of the nuclear industry in Australia.[4] On that same day, the Australian Labor Party (ALP) also adopted a new policy on uranium, abandoning its long standing "no new mines policy" to allow the mining and export of uranium on the basis of stated conditions.[5] However, the ALP remains "vehemently opposed" to the establishment of nuclear power plants and all other stages of the nuclear fuel cycle in Australia.[6]

With a federal election only weeks away and climate change firmly on the agenda, this essay describes the evolving policy on uranium and nuclear energy in Australia at the national level.

2. BACKGROUND

2.1 Australia's Uranium Resources

Australia possesses 38 percent of the world's identified low-cost uranium reserves, with identified uranium reserves of 1.2 million tonnes of uranium ore concentrate (U_3O_8).[7] Eighty-nine percent of Australia's total known uranium reserves are found within seven deposits: Olympic Dam, Jabiluka, Ranger, Yeelirrie, Kintyre, Valhalla and Koongarra.[8] Seventy percent of these reserves are located in the Olympic Dam deposit, which is the largest in the world. It is worth noting that low-cost does not equate to high grade, with Olympic Dam containing low grades of uranium, recovery of which is made economically viable because it is produced with gold and copper.[9]

Largely as a consequence of the ALP's "three mines policy" and State prohibitions on uranium mining, there are currently only three operating uranium mines in Australia: Ranger (an open-cut mine in the Northern Territory); Olympic Dam (an underground mine in South Australia); and Beverley (an in situ leach mine in South Australia). A fourth uranium mine, Honeymoon (an in situ leach mine in South Australia) has received approval and has set a target start-up date of mid-2008.[10]

In 2005, Australia produced 12 360 tonnes U_3O_8[11] accounting for approximately 23 percent of global production.[12] This production level was second only to Canada, which in that same year produced 13 713 tonnes U_3O_8, which equates to approximately 28 percent of global production.[13] By 2015, the overall production capacity from existing and approved uranium mines in Australia

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4 Prime Minister John Howard, "Uranium Mining and Nuclear Energy: A Way Forward for Australia", Media Release (28 April 2007), available at: http://www.pm.gov.au/media/release/2007/media_release24284.cfm.

5 Australian Labor Party, "National Platform and Constitution" (2007) at 55, available at www.alp.org.au/download/now/2007_national_platform.pdf [hereinafter National Platform].

6 Ibid at 56.

7 Uranium Mining, Processing and Nuclear Energy Review, *Uranium Mining, Processing and Nuclear Energy* (Canberra: Commonwealth of Australia, 2006) at 22 [hereinafter Switkowski Report]. Low-cost means in this context, uranium recoverable at costs of less than US$40 per kilogram of uranium.

8 Ibid. There are currently a total of 85 known uranium deposits and prospects across Australia.

9 Ibid. The grade in the Olympic Dam deposit averages 600 parts per million.

10 "New Australian Uranium Mine Re-Set for Mid 2008" (10 August 2007) Mineweb, available at: http://www.mineweb.net/mineweb/view/mineweb/en/page38?oid=24995&sn=Detail. Another deposit in South Australia, the Four Mile deposit, is reportedly also moving towards the approval stage.

11 Ibid.

12 UIF, op cit n 3 at 21.

13 Ibid at 21 and 22.

is forecast to almost double to more than 20,000 tonnes U_3O_8.[14] This figure increases to beyond 25,000 tonnes U_3O_8 if new mines from already identified deposits are included.[15] As a result of low prices and government policies, between 1975 and 2003 limited uranium exploration took place in Australia and there remains significant potential for further discoveries.[16]

2.2 Economic Factors

There is growing global interest in Australia's uranium reserves, with the combined effect of new nuclear power plants,[17] expanded capacity in existing plants and decrease in secondary supplies leading most commentators to predict increased global uranium demands.[18] The depletion of the secondary supply of highly enriched uranium from Russian weapons in 2013 will lead to further pressures.

Coupled with the growing demand, the spot price of uranium has increased very significantly, rising from approximately US$10/lb U_3O_8 in early 2003 to approximately US$75/lb U_3O_8 in October 1, 2007.[19] With the spot price of uranium closely linked to the price of energy, it is forecast to remain strong, at least in the short term. Although uranium is mainly sold under long-term contracts, the spot price has a flow on effect to the contract prices which are similarly expected to increase over time. Australian uranium exports earned A$573 million in 2005, with forecasts suggesting that before the end of 2010 this may exceed A$1 billion annually.[20]

2.3 Australia's Greenhouse Gas Emissions and Energy Demands

While Australia's contribution to global greenhouse gas (GHG) emissions is small, its national emissions are the 12th highest in the world and its per capita emissions amongst the highest in the world.[21] The country's high emission levels are largely a consequence of its ready access to low-cost fossil fuel reserves, around which a very energy-intensive economy has developed.[22] Indeed, from 1974-1975 to 2004-2005 electricity consumption more than tripled[23], a trend which shows little signs of abating. The Australian Bureau of Agriculture and Resource Economics (ABARE) projects a 46% increase in Australia's primary energy consumption from 2004-2005 to 2029-2030,

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14 Switkowski Report, op cit n 7 at 24.

15 Ibid.

16 Ibid.

17 Primary demand is expected to come from China, Indian and South Africa. As of 17 October 2007, nuclear reactors were under construction, planned or proposed in Argentina, Armenia, Bangladesh, Brazil, Bulgaria, Canada, China, the Czech Republic, Egypt, Finland, France, Hungary, India, Indonesia, Iran, Israel, Japan, Kazakhstan, Korea, DPR (North), Korea RO (South), Lithuania, Mexico, Pakistan, Romania, Russia, Slovakia, Slovenia, South Africa, Switzerland, Thailand, Turkey, Ukraine, United States and Vietnam (World Nuclear Association, 'World Nuclear Reactors 2004-06' (as of 17 October 2007), available at http://www.world-nuclear.org/info/reactors.htm).

18 Switkowski Report, op cit n 7 at 26. Secondary supplies have come from "stockpiles, reprocessing of spent fuel and the down-blending of highly enriched uranium from weapons."

19 Cameco Corporation, *Uranium Price*, available at: http://www.cameco.com/investor_relations/ux_history/. The spot price hit a record high of US$120/lb in May 2007.

20 Switkowski Report, op cit n 7 at 22.

21 Prime Ministerial Task Group on Emissions Trading, *Report of the Task Group on Emissions Trading*. (Canberra: Commonwealth of Australia, 2007) at 20-22.

22 Department of Prime Minister and Cabinet, *Energy White Paper, Securing Australia's Energy Future* (Canberra: Commonwealth of Australia, 2004) at 1 [hereinafter the Energy White Paper].

23 Switkowski Report, op cit n 7 at 45.

a rate well in excess of population growth over this period.[24] If growth continues as predicted, over 100 gigawatts (GW) of additional generating capacity will be required by 2050 to meet the growing demand.[25]

At present, the vast majority of electricity in Australia is generated by fossil fuels (black coal-56.0%, brown coal-20.9%, gas-14.3% and oil-1.4%), a situation predicted to continue into the future absent a change in energy policy. [26]

3. URANIUM, NUCLEAR ENERGY AND ENERGY POLICY

3.1 Policy developments through to 2004

In 1948, a major uranium deposit was discovered at Rum Jungle in the Northern Territory, which became the first of several uranium mines in Australia.[27] On Australia Day, 1958, Australia's first nuclear research reactor, located in Lucas Heights, Sydney, began operations. Eleven year later, plans to build a nuclear power station on Commonwealth land at Jervis Bay, New South Wales were approved.[28] In the face of growing anti-nuclear demonstrations and concern relating to the possibility of Australia producing nuclear weapons, the project was cancelled.[29] There has not since been serious consideration of a nuclear power station proposal in Australia.

In 1975, mounting community opposition to new uranium mines led the then Labor Prime Minister Gough Whitlam to establish a Commission to inquire into the environmental aspects of a proposal to mine the uranium deposit at the Ranger site in the Northern Territory. Established under the *Environment Protection (Impact of Proposals) Act 1974*, the Ranger Uranium Environmental Inquiry considered the "environmental"[30] aspects of the proposal as well as the question of mining uranium more broadly. The resulting Fox Report, as it is known, concluded that "the hazards of mining and milling uranium, if those activities are properly regulated and controlled, are not such as to justify a decision not to develop Australian uranium mines".[31] In so doing, however, it also recommended that "[p]olicy respecting Australian uranium exports, for the time being at least, should be based on a full recognition of the hazards, dangers and problems of and associated with the production of nuclear energy, and should therefore seek to limit or restrict expansion of that production."[32] To deal with the serious issues associated with weapons proliferation, "the most serious danger",[33] the Report recommended that "no sales of Australian uranium should take place to any country not party to the [Nuclear Non-Proliferation Treaty]".[34]

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24 C Cuevas-Cubria & D Riwoe, *Australian Energy: National and State Projections to 2029-30* (Canberra: ABARE, Dec 2006) at 27.

25 Switkowski Report, op cit n 7 at 45.

26 Australian Bureau of Agricultural and Resource Economics, *Energy in Australia* (Canberra: ABARE, 2006 at 45.

27 Four Corners, "Chronology-Australia's Nuclear Political History", Australian Broadcasting Corporation (2005), available at: http://www.abc.net.au/4corners/content/2005/20050822_nuclear/nuclear-chronology.htm.

28 Ibid.

29 Ibid.

30 The *Environment Protection (Impact of Proposals) Act 1974* defined "environment" as "all aspects of the surroundings of man, whether affecting him as an individual or in his social groupings".

31 Chair: Mr Justice R W Fox, *Ranger Uranium Environmental Inquiry, Report No 1* (Canberra: Government of Australia, 1976), recommendation 1 at 185 (hereinafter Fox Report).

32 Ibid, recommendation 7 at 185.

33 Ibid at 178.

34 Ibid, recommendation 8 at 185.

Before the Fox Report was presented, a Liberal/National coalition resumed power. In the years that followed, approval was given to mine uranium at the Ranger, Nabarlek and Olympic Dam sites. In 1977, while in opposition, the ALP adopted a policy which committed a future ALP Government to "declare a moratorium on uranium mining and treatment and a repudiation of commitments to mining, processing or export made by a non-Labor government".[35] However, faced with significant issues around the implementation of this policy, when federal Labor resumed power in 1984 it instead adopted a compromise position – the no new mines policy. This policy confined uranium production in Australia to the three sites being mined at that time. The no new mines policy was abandoned at the federal level when the Liberal/National coalition won the federal election in 1996.

3.2 Energy White Paper: Securing Australia's Energy Future

In 2004, the Australian Government released an Energy White Paper called *Securing Australia's Energy Future*. The Energy White Paper sought to establish a long-term national framework with the objective of ensuring "that Australians have reliable access to competitively priced energy, the value of energy resources is optimized, and environmental issues are well-managed."[36] Put another way, the objectives were to achieve "prosperity, security and sustainability".[37]

A theme in the Energy White Paper is the "further sustainable development" of Australia's low-cost energy resources, including Australia's low cost uranium reserves.[38] Indeed, the Energy White Paper credits the mining and export of uranium with reducing the "greenhouse intensity of other nations by reducing the need for higher-emission energy sources."[39] However, "cost, safety and waste disposal issues in power generation" are identified as existing impediments to the use of uranium as a domestic energy source.[40]

3.3 House of Representatives Standing Committee on Industry: Prosser Inquiry

In March 2005, a House of Representatives Standing Committee on Industry and Resources was formed to inquire into and report on the development of the non-fossil fuel energy industry in Australia. The Committee commenced its inquiry with a case study into the strategic importance of Australia's uranium resources, having particular regard to the:[41]

(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

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35 Senator Chris Evans, "Australian Uranium – A Labor Perspective", Speech to the Australian Uranium Conference (25 July 2007) at 3.

36 Energy White Paper, op cit n 22 at 2.

37 Ibid at 2.

38 Ibid at 3. See also pp 41 and 45 where this theme is further developed.

39 Ibid at 46.

40 Ibid at 135.

41 House of Representatives Standing Committee on Industry and Resources, *Australia's Uranium – Greenhouse Friendly Fuel for an Energy Hungry World: A case study into the strategic importance of Australia's non-fossil fuel energy industry* (Canberra: Commonwealth of Australia, Nov 2006) at xxi (hereinafter Prosser Inquiry).

The report, titled *Australia's Uranium – Greenhouse Friendly Fuel for an Energy Hungry World*, concluded that the use of nuclear power represents an important GHG mitigation option and endorsed Australia's role in mining and exporting uranium to fuel nuclear power. The Committee noted in its conclusions on GHG mitigation "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."[42] In this vein, the Chairman Geoff Prosser stated that "the Committee wholeheartedly agrees with a submitter who stated that through its supply of uranium 'Australia should throw the world a climate lifeline.'"[43]

In addition to its GHG benefits, the Committee also endorsed the strategic importance to Australia of mining and exporting uranium. It recognised both the economic benefits flowing from the export of uranium ("reflecting a happy coincidence of national self-interest and environmental altruism"[44]) as well as the potential energy security benefits available to countries choosing to adopt nuclear power.

The Committee also stated that it had no "in principle objection to the use of nuclear power in Australia" noting that there "would be clear greenhouse gas emission and other technological and potential economic benefits from doing so."[45] Recognising that nuclear power would not be cost competitive in Australia, the Committee believed that nuclear energy should be able to access the government incentives available to other low-emission technologies.[46]

3.4 Uranium Mining, Processing and Nuclear Energy Review Taskforce: The Switkowski Report

In June 2006 the Prime Minister appointed the Uranium Mining, Processing and Nuclear Energy Review Taskforce, chaired by Dr Ziggy Switkowski, to undertake "an objective, scientific and comprehensive review into uranium mining, value-added processing and the contribution of nuclear energy in Australia in the longer term."[47] The Taskforce was tasked very explicitly with inquiring into the role of nuclear energy in Australia's energy mix.

Given Australia's substantial low-cost uranium reserves and existing contribution to global production, the Switkowski Report concluded that Australia was "well positioned to increase production and export of uranium oxide to meet market demand".[48] It also saw an "opportunity for Australia to be a participant in the wider nuclear fuel cycle given international confidence in the quality of our production processes, our sophisticated technology community … and the strength of our commitment to non-proliferation."[49]

In relation to domestic energy needs, the Switkowski Report acknowledged that the priority for Australia will continue to be the reduction of CO_2 emissions from coal and gas.[50] Given Australia's increasing electricity demands, the need for additional capacity to be near-zero GHG emitting technology simply to maintain Australia's GHG emission levels at today's levels, and the much lower greenhouse signature of nuclear power than current major sources for electricity, the

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42 Ibid at 206.
43 Ibid at xvii.
44 Ibid at 498 where the Committee quotes and concerns with this view as expressed by UIC.
45 Ibid at 686.
46 Ibid.
47 Ibid at 1.
48 Ibid.
49 Ibid.
50 Ibid.

Taskforce also "[saw] nuclear power as a practical option for part of Australia's electricity production".[51]

The key findings of the Switkowski Report included:[52]

- Nuclear power is likely to be between 20 and 50 per cent more costly to produce than power from a new coal-fired plant at current fossil fuel prices in Australia. This gap may close in the decades ahead but nuclear power, and renewable energy sources, are only likely to become competitive in Australia in a system where the costs of greenhouse gas emissions are explicitly recognised. Even then, private investment in the first-built nuclear reactors may require some form of government support or directive.
- The earliest that nuclear electricity could be delivered to the grid would be 10 years, with 15 years more probable.
- The challenge to contain and reduce greenhouse gas emissions would be considerably eased by investment in nuclear plants. Australia's greenhouse challenge requires a full spectrum of initiatives and its goals cannot be met by nuclear power alone. The greenhouse gas emission reductions from nuclear power could reach 8 to 17 per cent [relative to business as usual] of national emissions in 2050.
- Disposal of high-level waste including spent nuclear fuel remains an issue in most nuclear power countries. Australia has areas suitable for [deep repositories] which would not be needed until around 2050 should nuclear power be introduced.

3.5 Current Policies on Uranium and Nuclear Mining

3.5.1 The Coalition government policy

Responding to the Switkowski Report, the Prosser Inquiry, and the recommendations of the Uranium Industry Framework,[53] on 28 April 2007 the Coalition government adopted a new uranium strategy designed to increase uranium exports and prepare for the possible expansion of the nuclear industry in Australia.[54]

The media release announcing the new strategy stated:[55]

> Nuclear energy is a fact of life and a key source of clean energy in 30 countries across Europe, Asia and North America ... Australia has 36 per cent of the world's low cost uranium reserves. Policies or political platforms that seek to constrain the development of a safe and reliable Australian uranium industry - and which rule out the possibility of climate-friendly nuclear energy - are not really serious about addressing climate change in a practical way that does not strangle the Australian economy.

The strategy contemplates a number of actions, including:[56]

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51 Ibid.

52 Ibid at 2.

53 UIF, op cit n 3. The Uranium Industry Framework was initiated in August 2005 with the objective of "identifying opportunities for, and impediments to, the further development of the Australian uranium mining industry over the short, medium and longer term". It was developed in partnership with relevant State and Territory Governments, industry and other stakeholders.

54 Prime Minister John Howard, "Uranium Mining and Nuclear Energy: A Way Forward for Australia", Media Release (28 April 2007), available at: http://www.pm.gov.au/media/release/2007/media_release24284.cfm.

55 Ibid.

- removing unnecessary constraints impeding the expansion of uranium mining, such as overlapping and cumbersome regulations relating to the mining and transport of uranium ore;
- repeal of the Commonwealth legislation prohibiting nuclear activities, including the relevant provisions of the *Environmental Protection and Biodiversity Conservation Act 1999* (Cth); and
- making a firm commitment to Australia's participation in the Generation IV advanced nuclear reactor research programme.

The strategy also provides for the development of four major work plans relating to:[57]

(i) an appropriate nuclear energy regulatory regime – including those to govern any future potential nuclear energy facilities in Australia;

(ii) skills and technical training to address any identified gaps and needs to support a possible expanded nuclear energy industry;

(iii) enhanced research and development; and

(iv) communication strategies so that all Australians and other stakeholders can clearly understand what needs to be done and why.

3.5.2 The ALP policy

On 28 April 2007, the ALP also adopted a new policy on uranium. Although it "recognises that the production of uranium and its use in the nuclear fuel cycle present unique and unprecedented hazards and risks", the new ALP policy allows for the mining and export of uranium on the basis of stated conditions.[58] When addressing the ALP National Conference in the context of amending the ALP's policy on uranium, the Leader of the Opposition, Kevin Rudd, explained the underlying rationale for this policy change on the basis of global energy supply, rather than greenhouse policy:[59]

> As I said before other countries in the world are not as rich in energy options as we are here today in Australia. And that is why over a long period of time our country has been exporting uranium for the rest of the world. And that is why the amendment before you seeks to recognise that reality.

While endorsing Australia's participation in the nuclear fuel cycle to this extent, the new ALP policy "prohibits the establishment in Australia of nuclear power plants and all other stages of the nuclear fuel cycle" and remains "strongly opposed to the importation of nuclear waste…".[60] It necessarily follows that the ALP policy on climate change does not include nuclear energy, focusing instead on renewable energy and "clean coal" technologies to offer low emission energy appropriate for Australia's energy mix.[61]

3.5.3 State Government policy

Differences in State government policies on uranium mining and nuclear energy further complicate the overall picture in Australia. With the exception of South Australia and the

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56 Ibid.
57 Ibid.
58 National Platform, op cit n 5 at 55.
59 Kevin Rudd, Uranium Debate – Speech to ALP Conference (28 April, 2007), available at: http://www.alp.org.au/media/0407/speloo281.php.
60 Ibid at 56.
61 Ibid at 137-138.

Northern Territory,[62] the State governments have retained policies which prevent uranium mining.[63] Uniform in their opposition to nuclear facilities within their respective jurisdictions, each State has, or is progressing, legislation which prohibits the construction and operation of nuclear facilities.[64]

4. THE ROLE OF URANIUM AND NUCLEAR ENERGY IN THE ENERGY MIX

Any discussion of uranium and nuclear energy policy necessarily raises a myriad of very significant issues relating to health and safety, environmental impacts, the proliferation of nuclear weapons and security, and radioactive waste management. Indeed, these issues remain as relevant and vexed today as they were over thirty years ago when the Fox Report inquired into the broader issues associated with the mining of Australia's uranium.[65] However, the redefinition of nuclear energy as a "clean" energy source has added a new dimension to the debate, and is a primary driver behind the current policy developments. Given this, it is relevant to explore here whether nuclear power is "the cleanest and greenest power generation source of all."[66] In so doing, it is necessary to note that there is a great deal of contention around these issues. As Professor Ian Lowe said in his recent essay on this issue, "[t]here is no objective truth about the future performance, cost, safety of nuclear reactors. There is a range of defensible opinions, as well as some that appear indefensible … We are all influenced by our experience, our culture and our values in trying to make sense of complex and uncertain issues. So you should read all statements about the nuclear issue … with a critical eye."[67]

4.1 Is Nuclear Energy "clean"?

Nuclear power plants do not emit combustion gases while generating electricity and so in that sense, they are a "CO_2-free energy source at point of generation."[68] However, there are GHG emissions associated with the mining and milling of uranium, the enrichment process, fuel

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62 The Australian Government has the power to approve new mines in the Northern Territory pursuant to its powers in the *Atomic Energy Act 1953*.

63 In Victoria and New South Wales there are legislative prohibitions against the exploration and mining of uranium (*Nuclear Activities (Prohibition) Act 1983* (Vic), s 5 and *Uranium Mining and Nuclear Facilities (Prohibitions) Act 1986* (NSW), s 3). While it is possible to explore for uranium in West Australia and Queensland, as a matter of policy neither of these state governments will grant mining leases for the purposes of mining uranium.

64 See: *Nuclear Facilities Prohibition Bill 2007* (WA); *Nuclear Facilities Prohibitions Act 2007* (Qld); *Nuclear Waste Storage Facility (Prohibition)(Prohibition of Other Nuclear Facilities) Amendment Bill 2007* (SA); *Uranium Mining and Nuclear Facilities (Prohibitions) Act 1986* (NSW); and, the *Nuclear Activities (Prohibitions) Act 1983* (Vic).

65 Fox Report (op cit n 31), canvassed issues relating to hazards of the nuclear fuel cycle (chapter 10), environmental hazards of non-nuclear energy sources (chapter 11), safeguards against diversion to weapon-making (chapter 12), weaknesses in the Non-Proliferation Treaty and of the Safeguards System (chapter 13), nuclear theft and sabotage (chapter 14).

66 Prime Minister John Howard is quoted saying, in a parliamentary debate on climate change, "Let me say to the climate change purists, or the climate change fanatics (in Labor), the cleanest and greenest energy source of all is the one you won't look at, and that's nuclear power." ("PM Labels Labor Climate Change 'Fanatics'", *Daily Telegraph* (6 Feb 2007),
available at: http://www.news.com.au/dailytelegraph/story/0,22049,21182101-5001028,00.html.

67 Lowe, op cit n 1 at 3.

68 Prosser Inquiry, op cit n 41 at 151, quoting Paladin Resources Ltd. *Submission No 47* at p 5. In comparison, coal, oil and natural gas releases approximately 4, 3.2, and 2.3 tonnes of CO_2 respectively for every tonne of oil equivalent burned.

fabrication, transport, plant construction and operation, plant decommissioning and waste management.

It is not possible to estimate these life cycle emissions precisely, as estimates are dependant on plant characteristics, the grade of uranium ore mined and the diffusion technology used for enrichment. The Switkowski Report concluded that most published studies estimated the emissions intensity of nuclear power on a life cycle basis to be between 2 and 40 kg CO_2 equivalent per megawatt hour (CO_2-e/MWh).[69] A University of Sydney study commissioned for the Switkowski Report to estimate the life cycle GHG emissions intensity of nuclear energy produced in Australia (using light water reactors) produced an estimate of around 60 kg CO_2-e/MWh (within a range of 10-130 kg CO_2-e/MWh).[70] This intensity range is well below the same study's estimates for brown coal at 1175 kg CO_2-e/MWh (1011-1506 kg CO_2-e/MWh), black coal (supercritical) at 863 kg CO_2-e/MWh (77-1046 kg CO_2-e/MWh), black coal (new subcritical) at 941 kg CO_2-e/MWh (843-1171 kg CO_2-e/MWh), natural gas (open cycle) at 751 kg CO_2-e/MWh (627-891 kg CO_2-e/MWh) and natural gas (combined cycle) at 577 kg CO_2-e/MWh (491-655 kg CO_2-e/MWh).[71]

However, when the life cycle GHG emission intensity of nuclear energy is compared with renewable energy technologies, the picture is very different. While the University of Sydney estimates of GHG emission intensity of solar photovoltaics, at 106 kg CO_2-e/MWh (53-217 kg CO_2-e/MWh), are above those of nuclear energy, its estimates for wind turbines, at 21 kg CO_2-e/MWh (13-40 kg CO_2-e/MWh), and hydroelectricity, at 15 kg CO_2-e/MWh (6.5-44 kg CO_2-e/MWh), are significantly below.[72]

One of the important assumptions in estimating life cycle emissions is the uranium ore grade. As the University of Sydney study states, the overall energy intensity of nuclear energy depends critically on the grade of uranium ore mined, together with the method of enrichment and the conversion rate of the nuclear fuel cycle.[73] The greenhouse intensity of nuclear energy, in turn, "depends critically on the energy intensity, the method by which energy for enrichment is generated and the GHG intensity of the economy.[74] For the purposes of the University of Sydney study, it was assumed that uranium is recovered from ore of 0.15 per cent grade, which is typical grade for the Beverly and Ranger deposits, and that the full energy requirement for recovery was attributable to uranium.[75]

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69 Switkowski Report, op cit n 7 at 93.

70 ISA, *The University of Sydney, Life-Cycle Energy Balance and Greenhouse Gas Emissions of Nuclear Energy in Australia* (A study undertaken for the Department of Prime Minister and Cabinet of the Australian Government: 3 November 2006) at 7 (hereinafter the University of Sydney). The lower end of this range "would only be seen" if centrifuge only enrichment was used or the Australian economy had a lower overall energy intensity and the higher if extremely low grade ores were mined (at 93). For a full discussion of the several assumptions built into this study readers are directed to the study.

71 Ibid at 8.

72 Ibid. Others have concluded that while the lifecycle and fuel cycle GHG emissions of nuclear power plants are significantly lower than fossil fuels, they are still three to four times as high as for renewables per unit of energy (George Wilkenfeld, Clive Hamilton and Hugh Saddler, ''Clean Coal' and other Greenhouse Myths'" (Aug 2007) The Australia Institute Research Paper No 49.

73 University of Sydney, ibid at 6.

74 Ibid at 7.

75 Ibid at 5.

There are, however, limits on the availability of high-grade ores, with known reserves estimated to supply present demand for approximately fifty years.[76] This reserve will of course be depleted more quickly if the demand for uranium increases. As supplies of high grade ore are diminished, increased energy inputs will be required to mine and process lower grade uranium ores, reducing the net emissions savings from nuclear power.[77] Indeed, some studies have concluded that fueling nuclear power stations from lower-grade ores results in more CO_2 per unit of energy delivered than burning gas.[78] While the conclusions in that study have been "comprehensively critiqued"[79] it is the case that as ore grades decline, the fuel energy required to produce them, together with the associated CO_2 emissions rise.[80] Assuming that fuel energy is provided by fossil fuels, this will narrow the emission advantage nuclear energy offers in relation to fossil fuels and widen the gap with renewable energy sources.[81]

Therefore, nuclear energy is cleaner, in the context of GHG emissions intensity, than fossil fuel energy using current technology. It is not, however, cleaner than most sources of renewable energy and may become less so as high grade ore reserves are depleted.

4.2 Is Nuclear Energy Green?

Three categories of radioactive waste are produced throughout the nuclear fuel cycle: low-level waste, intermediate-level waste and high-level waste (HLW). HLW, which includes spent nuclear fuel and the waste stream from reprocessing spent nuclear fuel, is by far the most hazardous. Before the Prosser Inquiry, Dr Helen Caldicott gave evidence that in the process of fissioning:[82]

> [the fuel becomes] one million times more radioactive than the original uranium [and] … two hundred new elements are made, all of which are much more dangerous and radioactive than the original uranium. That is nuclear waste. Some last for seconds and decay. Some last for millions of years.

According to the Switkowski Report "as the potential hazard from HLW is greatest in the first few hundred to 1000 years, the geological repository must isolate waste from the biosphere over this period."[83] Beyond that, HLW from reprocessing spent nuclear fuel presents "a greatly decreased

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76 Lowe, op cit n 1 at 23. In relation to ore grade, of note is the following: "As a conservative estimate, we assume that all uranium is mined at Australia's Ranger (NT) and Beverley (SA) mines (0.15per cent U3O8), and that this uranium is not accompanied by any primary product or by-product, so that the full mining energy requirement is attributable to uranium. Had we assumed conditions as in the Olympic Dam mine, the ore grade would have been lower (around 0.05per cent), however most energy requirements would have been attributable to the recovered copper" (at p 96).

77 Ibid. See also Prosser Inquiry, op cit n 41 at 168-172 for an overview of submissions on this issue.

78 Lowe, ibid at 23. See also: Storm van Leeuwen and Smith, "Nuclear Power: the Energy Balance", available at: http://www.stormsmith.nl/report20050803/Chap_1.pdf; and, Dr Jim Green, *Nuclear Power: No Solution to Climate Change* (September 2005) at heading 2.2.

79 Prosser Inquiry, op cit n 41 at 171 referring to published responses to this study by Uranium Information Centre, World Nuclear Association and academics from the School of Physics at the University of Melbourne. The University of Sydney study notes that if the assumptions adopted in studies conducted by Storm van Leeuwen and Smith are adopted and the ore grade drops down to 0.01per cent, the nuclear fuel cycle would "not longer produce net energy, and its greenhouse gas emissions would be comparable to a gas-fired power plant" (University of Sydney, op cit n 70) at 64.

80 Lowe, op cit n 1 at 23 and University of Sydney, ibid.

81 Green, op cit n 78. See also: Lowe, ibid.

82 Prosser Inquiry, op cit n 41 at 224 quoting Dr Helen Caldicott, *Transcript of Evidence*, 16 September 2005 at 3.

83 Switkowski Report, op cit n 7 at 62.

potential hazard"[84] but it is not until "around 10,000 years, that the level of activity is approximately the same as that in the original uranium ore body." However, protection from the release of radioactive materials is required beyond this period for long-lived radioactive elements.[85] In the case of spent nuclear fuel "radioactivity does not decline to that of the original uranium ore body for about 200 000 years because of the time required for decay of actinides and long-lived fission products in the fuel."[86]

The Switkowski Report and Prosser Inquiry indicate that "there is broad scientific and technical consensus that HLW can be safely disposed of at depths of hundreds of metres in stable geological formations"[87] and identify advances being made around the world towards the construction of HLW geological disposal facilities.[88] However, after over fifty years of nuclear power and the generation of 270 000 tonnes of spent fuel worldwide,[89] no country has yet implemented permanent underground disposal of HLW.[90]

As the Fox Report recognised 30 years ago, a significant distinguishing feature between nuclear energy and other types of energy is that nuclear energy produces radioactive waste. While the Fox Report concluded that waste issues did not justify Australia wholly refusing to export uranium at that time, it did recognise that high level waste resulting from the production of nuclear energy constituted a serious potential problem. In this respect, the Report stated, "[i]f, even in a few years, satisfactory disposal methods have not been established, it may well be that supplies of uranium by Australia should be restricted, or even terminated."[91]

As Professor Ian Lowe notes, developing systems to isolate radioactive waste for hundreds of thousands of years is more than a technical issue. It is also "a huge challenge for our social institutions, as it obliges us to consider a time-scale much longer than any human society has lasted, of the same order of magnitude as our entire existence as a species."[92]

Given the radioactive waste produced by nuclear energy, it is very difficult to suggest nuclear energy is green in an absolute sense.

4.3 Is Nuclear Power the Cleanest and Greenest Energy Source of All?

Given that most renewable energy sources have a lower GHG emission intensity than uranium and that none produce radioactive waste, many argue that they are, in fact, the "cleanest and greenest energy source of all" and there is no need to add nuclear power to the energy mix.

While not every country is as well positioned to take advantage of renewable energy, Australia is very well endowed with this resource. The majority of Australia receives 1600 Kilowatt hour (kWh) per square metre per year of solar radiation, with some areas receiving up to 2,500 kWh per

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84 Ibid.

85 Ibid. The Report does indicate that more sophisticated fuel cycles do not separate the transuranics in processing, which reduces the "long-lived burden" (at 62).

86 Ibid.

87 Ibid at 64. See also: Prosser Inquiry, op cit n 41 at 236.

88 Ibid at 64.

89 Prosser Inquiry, op cit n 41 at 236. See also Lowe, op cit n 1 at 22, who refers to an accumulation of 250 million tonnes of radioactive waste, of which 10,000 tonnes of it is highly radioactive.

90 In 1954, the Obninsk Nuclear Power Plant in Russia became the first nuclear power plant to generate power for commercial use. Two years later, the first commercial nuclear power plant, Calder Hall 1, commenced operations in England (European Nuclear Society, *Nuclear Power-Plants Worldwide,* available at: http://www.euronuclear.org/info/npp-ww.htm).

91 Fox Report, op cit n 31 at 178.

92 Lowe, op cit n 1 at 22.

square metre per year.[93] This amounts to only 10 percent less solar radiation than that received by the most solar radiation rich place on earth, the Sahara Desert.[94] The potential to exploit wind energy is similarly high in Australia, with "one of the strongest and most abundant wind resources on the planet"[95]. New renewable energy prospects, including hot dry rocks geothermal and wave power, are also in generous supply.

However, it is argued that nuclear energy must be given a place in Australia's energy mix to deliver low emission baseload energy.[96] The Switkowski Report concluded that "nuclear energy is the least-cost low emission technology that can provide base-load power, is well established and can play a role in Australia's future generation mix."[97] A media release issued on 23 August 2007 by Prime Minister John Howard stated: "[i]f Australia is serious about addressing climate change it must consider adding nuclear power to its energy mix, as many other countries are already doing. Nuclear power is the only reliable source of low emission baseload power now available."[98]

There are several points to note here. First, commentators such as Professor Lowe suggest that Australia's real demand for baseload power is relatively low.[99] He notes that current baseload demands have been artificially inflated by incentives offered to shift energy to off-peak, in order to take advantage of spare capacity offered by large power stations made cost-effective by running day and night.[100]

Second, there is a further contender to deliver low emission baseload power. Australia's Chief Scientist, Dr Jim Peacock, puts clean coal forward with nuclear power as the "two modes of power generation capable of base-load power production which can be operated without serious consequences for climate change emission."[101] While party policies diverge on the use of nuclear power, both main parties are committed to investing in technology to reduce emissions from coal to protect the future of the Australian coal industry.

Finally, innovation in the renewable sector holds the promise of delivering baseload supply. Solar company Ausra believes it is close to delivering baseload power using solar technology.[102] According to Dr Mills, an Australian solar expert leading the Ausra project in California, "in five years time, we'll have very large plants and I would say gigawatt-style plants already commissioned, able to run 24 hours a day and completely replace the function of nuclear and coal plants".[103] Hot dry rock geothermal energy "has the potential to provide secure, reliable base load

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93 R Lyster, and A Bradbrook, *Energy Law and the Environment* (Cambridge University Press, 2006), p 16.

94 Ibid.

95 University of Sydney, op cit n 70, quoting the International Energy Agency, "Annual Report – Chapter 4 – Australia" (2004).

96 Baseload power is "the level of electricity demand that exists twenty-four hours a day" (Lowe, op cit n 1 at 37.

97 Switkowski Report, op cit n 7 at 45.

98 Prime Minister of Australia, "Nuclear Power Station Plebiscites", Media Release (23 August 2007).

99 Lowe, op cit n 1 at 37.

100 Ibid.

101 Dr Jim Peacock, "Letter to The Hon John Howard AP" (21 December 2006), available at: http://www.dpmc.gov.au/publications/umpner/docs/letter_to_PM_20061221.pdf.

102 Matt Peacock, "Solar takes off with US Power Supply Deal" (ABC News, October 2, 3007).

103 Ibid.

power and can be built within one or two years."[104] Advances in wave power[105] also promise the generation of baseload power.

5. CONCLUSION

With 443 nuclear reactors already operating in 31 countries around the world, producing 15 percent of the world's electricity,[106] nuclear energy is firmly established as a part of the global energy mix. One in which Australian uranium already plays a major role. The policies of the Coalition and the ALP both support a continued and indeed expanded role in uranium mining. It is on the role of nuclear power in the Australian energy mix that policies diverge. Ultimately, whether nuclear power may form part of Australia's energy mix, at least in the near term, will depend on the outcome of the upcoming federal election.

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104 Geothermal energy "has the potential to provide secure, reliable base load power and can be built within one or two years". (Kevin Rudd, "An Action Agenda for Climate Change", Annual Fraser Lecture (30 May 2007) at 12.

105 For a discussion of this developing technology, see the Carnegie Corporation Ltd website at: http://www.carnegiecorp.com.au/index.php?url=/ceto/ceto-overview.

106 Switkowski Report, op cit n 7 at 7.