Research Papers of the Parliamentary Library Service, no.4/2006
Northern Territory Library

Radioactive waste management

Third in the series on the *Debate on Nuclear Policy in Australia, 2005-2006*

Brian Lloyd

Northern Territory Government
Department of Local Government, Housing and Sport

Published by the Parliamentary Library Service, Northern Territory Library 2006

GPO Box 42, Darwin, NT, 0801.

email: parlibrary.dlghs@nt.gov.au

phone: 08 8999 1776

The author may be contacted at: brian.lloyd@nt.gov.au

ISSN 1833-8771

National Library of Australia Cataloguing-in-Publication entry:

Lloyd, Brian.
Radioactive waste management : third in the series on the debate on nuclear policy in Australia, 2005-2006.

Bibliography.
ISBN 9780977563432 (pdf).

ISBN 0 9775634 3 X (pdf).

1. Radioactive waste disposal - Government policy - Australia. 2. Nuclear energy - Government policy - Australia. I. Title. (Series : Research papers of the Parliamentary Library Service ; 3/2006).

363.728970994

NORTHERN TERRITORY LIBRARY

Northern Territory Government
Department of Local Government, Housing and Sport

Abstract

Radioactive waste is one of the most emotive issues in the current debate on Australia's nuclear involvement. Many nuclear proponents share, with their opponents, an acceptance that radioactive waste is integral to the use of nuclear materials, from medical applications to power generation. It is the value attributed to that waste — how much of a risk, how great or how small in orders of size — that is at issue. This part of the debate is of central importance, for can we contemplate an expansion in nuclear activities — mining, export, possibly uranium enrichment, and the domestic use of nuclear power — without clear answers to questions over whether we can manage, safely and successfully, the higher volumes of radioactive waste that would arise from such a change of direction?

Table of Contents

Definitions

Half-life - time period over which half of the radioactivity in a body of material has changed, over time, to a low energy state.

Radioactive waste is by convention divided into four categories:

Low Level Waste (LLW) — requiring containment but no shielding;

Intermediate Level Waste (ILW) — requiring shielding but no specific measures for heat dispersal. It is divided into Intermediate Level Waste, short-lived, which has a half-live of less than thirty years, and Intermediate Level Waste, long-lived, with a half-life of more than thirty years;

High Level Waste (HLW) — requiring both shielding and dissipation of heat arising from the material.[1]

Radioisotopes – high energy-state forms of the chemical elements. Radioisotopes progressively 'decay' to lower energy state forms, known as 'daughters', over time.

Acronyms

ANSTO – the Australian Nuclear Science and Technology Organisation

ARPANSA – the Australian Radiation Protection and Nuclear Safety Agency

HRSCIR - The House of Representatives Standing Committee on Industry and Resources

[1] See Department of Education, Science and Training (2005)

Introduction

Radioactive waste is one of the most emotive issues in the current debate on Australia's nuclear involvement. As we shall see, many nuclear proponents share, with opponents, an acceptance that radioactive waste is integral to the use of nuclear materials, from medical applications to power generation. It is the value attributed to that waste — how much of a risk, how great or how small in orders of size — that is at issue. As for other topics in the area, we see that scientific data is often used to support existing positions, rather than as a basis from which to deduce one. In short, this is a debate dominated by partisan views. At the same time, it brings forward questions of central importance: *can* an expansion in nuclear activities — mining, export, possibly uranium enrichment, and the domestic use of nuclear power — be countenanced in view of our current capacity to manage radioactive waste? *Are* we able to keep radioactive waste contained in such a way that it does not harm us or the environment, and what, realistically, *is* our ability to manage the higher volumes of waste likely to arise from a liberalisation of nuclear policy?

The present paper is the third in a series of seven on the current debate on Australian nuclear policy. The first introduced the series, and the second has looked at the present state of uranium mining, levels of demand for uranium, and issues over the current and projected levels of nuclear power generation, as drivers of demand. As do the other papers in the series, this paper looks at the arguments advanced on behalf of the affirmative and negative cases on the question: *should* Australian nuclear policy be liberalised?

As for other papers in the series, these arguments are drawn from selected submissions to an inquiry of the House of Representatives Standing Committee on Industry and Resources (HRSCIR), the *Inquiry into the Strategic Importance of Australia's Uranium Resources*. For the affirmative case, described under the heading 'For', are submissions by the Uranium Information Centre (UIC), the Australian Nuclear Scientific and Technology Organisation (ANSTO), and the Commonwealth Scientific and Industrial Research Organisation (CSIRO). For the negative case, described under the heading 'Against', are submissions by the Medical Association for the Prevention of War (MAPW), Friends of the Earth (FoE), and anti-nuclear activist Richard Broinowski. These are followed by a section entitled 'Correspondences', which draws links between the arguments considered on either side of the argument and those being aired in the news media, and by a Discussion and Conclusion, which consider the merits of arguments and draw deductions about the state of debate.

In a field as complex as this, definitions of terms are essential. What, then, is 'radioactive waste'? The term embraces a spectrum of cases: from low-activity material that results from the handling of radioactive sources; to tailings from the mining and refining of radioactive substances; to expended sources and irradiated materials from medicine and engineering; through to highly radioactive materials produced in nuclear reactors — for power or for other purposes. By convention, radioactive waste is divided into four categories. High Level Waste (HLW) generates both heat and substantial levels of radiation, requiring shielding and cooling. Intermediate Level Waste (ILW) requires shielding alone, and is subdivided into short and long-lived forms. Low Level Waste (LLW) only requires containment to prevent human contact or its dispersal into the environment (Holland, 2004). Out of these categories of waste, the HRSCIR submissions considered here focus almost exclusively on HLW, by virtue of the inquiry's focus on uranium, both as an export commodity and as a fuel. The submissions have considerably less to say about the Intermediate Level Waste (ILW) and Low Level Waste (LLW) that will concern residents of the Northern Territory if proposals for the National Radioactive Waste Facility go ahead, and for this reason the Waste Facility has been discussed in a previous *Research Paper* (Lloyd, 2006). In either case however, critical questions hinge on whether radioactive waste can be contained effectively, or whether it will over time inevitably leak into the environment to become a significant hazard.

'For'

Radioactive waste is a sensitive issue for nuclear proponents. Even arguments in favour of an expanded role for Australian uranium mining acknowledge the disposal of radioactive waste as a 'major issue that is inevitably linked to the production and exportation of uranium' (CSIRO, 2005, p.9). As a result, sources on this side of the debate strive to put radioactive waste — as a given of nuclear activities — in the best possible light.

One way nuclear proponents do this is by accepting the reality of nuclear waste, on one hand, while presenting views of it in such a way as to minimise perceptions of the volumes of waste involved, and levels of hazard associated with it. Proponents characterise nuclear waste as a 'contained' form of waste, contrasting it with that generated by other power technologies — particularly coal. The UIC does this, for example, when it describes the nuclear power industry as 'the only energy-producing industry [that] takes full responsibility for all its wastes' (Uranium Information Centre, 2005b, p.37). While the UIC acknowledges that waste management is a 'significant environmental consideration' for nuclear power, its view is that waste is created 'in relatively small quantities' due to 'the efficiency of nuclear fission' (Uranium Information Centre, 2005b, p.15). ANSTO, in its submission, takes a similar approach when it suggests that 'the spent fuel produced from all the world's reactors in a year … would fit into a structure the size of a soccer field and 1.5 meters high' — thus using an analogy with a deliberately familiar object to connote minimal cause for concern (ANSTO, 2005, p.[11]).[2] Consistent with this, the UIC argues that the absence of longer-term disposal solutions for nuclear waste has not been due to technical difficulties, but rather that it has simply been unnecessary until now due to low waste outputs (Uranium Information Centre, 2005b, p.21).

---

[2] ANSTO's submission is unpaginated: page numbers are provided here in square brackets.

These statements focus on the volume of radioactive waste. As suggested, there is also an argument as to the level of hazard it represents. The UIC, for example, suggests that levels of radioactivity in nuclear reactor waste fall dramatically over a reasonably short period, ‘due to the progressive diminution of radioactivity’, so that ‘after 40 to 50 years of storage, the radioactivity level of the fuel falls to 0.1% of its original level’ (Uranium Information Centre, 2005b, p.21). While the ensuing waste ‘must be stored and eventually disposed of carefully’, the ‘industry’s record of managing used civil fuel, over nearly 50 years’ has been ‘uneventful’ (Uranium Information Centre, 2005b, p.15). Nor should we be concerned about wastes occasioned by the decommissioning of nuclear power plants: in the UIC’s view, disassembling and disposal of static plant irradiated during the normal running of nuclear power plants is not problematic, for ‘99% of the radioactivity is associated with the fuel’ (Uranium Information Centre, 2005b, p.43). The majority of other contaminated materials take the form of short-lived ‘activation products’, which ‘after 50 years from closedown’, represent levels of hazard that are ‘much diminished’ (Uranium Information Centre, 2005b, p.43).

A third strand of this overall argument asserts that reprocessing spent fuel decreases levels of hazard. ANSTO’s submission argues that ‘about one third of the spent fuel that has ever been discharged has been reprocessed’, that is, that it has been separated into two streams: one of plutonium-rich material, and the second, relatively more manageable, consisting of ILW and LLW waste (ANSTO, 2005, pp.[10-11]). Moreover, if this point is accepted — as to the efficacy and practicability of reprocessing — the most radioactive components of spent fuel can be construed, as ‘fuel’ rather than ‘waste’, since plutonium from reprocessing can be used as a fuel input, together with fresh uranium, for Mixed Oxide (MOX) reactors. As a result, from this perspective, spent fuel may be considered an asset rather than a liability, and this makes a further contribution to the impression that HLW is responsive to methods for its management (Uranium Information Centre, 2005b, p.21).

This argument — that radioactive waste can be managed effectively through deliberate human effort, that it doesn’t represent an utterly intractable problem — of course must receive particular attention in connection with radioactive waste *disposal* — that is, within the context of a final destination for radioactive waste. The conventional model of radioactive waste management, for HLW, includes a period of storage in a retrievable (usually aboveground) configuration over a period of some decades, during which some radioactivity subsides, and heat can readily disperse. Disposal is the next stage in this model, in which waste is held over a very long-term period: for HLW in the order of some thousands of years, or hundreds of thousands of years.

While this model represents something of a contemporary consensus for radioactive waste management, it is just that — a model. Closer observation shows that while *storage* facilities are common, the state of play on the implementation of *disposal* facilities is still uncertain, and is itself subject to claim and controversy. Given the significance of this as an issue, nuclear proponents make considerable effort to convey the sense that arrangements for disposal are well in hand, and that questions about these arrangements are settled. The UIC, for example, describes ‘an international consensus that deep geological repositories are the safest, most appropriate way to dispose of high-level wastes’ and — more positively — that this is ‘a technology for which no technical impediments … have been demonstrated’ (Uranium Information Centre, 2005b, p.15). According to the UIC, arrangements are well under way: ‘high level waste repositories will be operational in several countries by about 2020 to provide for final disposal’ (Uranium Information Centre, 2005b, p.15). This message is amplified in statements that use, as far as possible, the present tense, conveying the sense that these arrangements are already in place:

> The waste products [from spent fuel] ... *are* immobilised in borosilicate glass which is packaged in heavily shielded containers in preparation for disposal in repositories deep underground. In other countries, the spent fuel *is* destined for direct disposal.
>
> Some intermediate level waste contains long-lived radionuclides in quantities that require a high degree of isolation from the biosphere. This *is* typically provided by disposal in geologic formations at a depth of several hundred metres. Such wastes currently remain in storage pending ultimate disposal (ANSTO, 2005, p.[10]). (my italics)

This way of presenting the current state of affairs implies that a solution for radioactive waste is a *fait accompli*. In this, Yucca Mountain in Nevada — as the most publicised proposed site for geological disposal — attracts a strong symbolic importance. If Yucca Mountain were to go ahead, it would appear to be an important proof that geological disposal is a viable solution to a difficult problem. The UIC’s rhetorical strategy in discussing the matter is to bring forward the commissioning of Yucca Mountain by stating that ‘the United States *is now* building’ a facility there, rather than exploring it as a possibility — a position quite different from other views discussed below (Uranium Information Centre, 2005b, pp.21-22)(my italics).

The overall message from the affirmative case is clear: because we can manage radioactive waste with confidence, we are free to mine and supply uranium ore; use nuclear fuels; and expand our capacity for nuclear power generation — without undue concern at the waste these actions will generate. From this perspective, concerns over an increased waste stream are exaggerated and unfounded and, therefore, an expanded nuclear industry may be considered a sustainable enterprise.

‘Against’

We have seen how the affirmative case portrays the waste arising from nuclear power generation as both small in quantity and less of a radiation hazard than may have been anticipated. Nuclear opponents take quite another view. In many cases, their emphasis is not so much on undifferentiated ‘radioactive waste’, as such, but on plutonium specifically. In this view, plutonium attracts a special focus because it is at once an inevitable product of uranium-fuelled nuclear reactors (through 'neutron capture')[3]; is a key component of nuclear weapons; and is a notoriously potent radio toxin. Plutonium's notoriety in the public mind — its level of recognition as an acute hazard — means that it tends to figure less in the arguments of nuclear proponents, where it is at a potential embarrassment (despite hopes for it as a fuel), than those of nuclear opponents. In their hands plutonium is, as an issue, a powerful signal that nuclear industries are not benign.

Nuclear opponents — in this case MAPW — argue that each 1000 megawatt nuclear reactor produces plutonium at a rate of 'around 300kg per year', resulting in 'long-lived and extremely dangerous' waste that requires 'hundreds of thousands to millions of year periods' to decay to safe levels of radioactivity (MAPW, 2005, p.15). In their view, the level of responsibility entailed in managing this material is 'unprecedented': not only has 'human capacity' failed to come anywhere near the levels required to meet such a task — by several 'orders of magnitude' — but 'no human institution has [ever] persisted for more than hundreds to thousands of years' (MAPW, 2005, p.15). This leaves an open question as to who will take responsibility for radioactive waste in the distant future (MAPW, 2005, p.15). The picture is a contrasting one to that described above: in this view, there are strong doubts as to whether waste can be stored, and then buried, with any clear sense of finality at all.

Speakers for the negative case also assign quite a different value to the level of hazard associated with radioactive waste, and with plutonium in particular. Barnaby describes the level of radio toxicity for 'typical reactor-grade plutonium'. For individuals, he suggests, an

> inhalation of about 60 micrograms will have a very high probability of causing a fatal cancer and the ingestion of about 3 milligrams will have a very high probability of causing a fatal cancer (Barnaby, 2000, [unpaginated]).

Extrapolating beyond individuals, to populations, Barnaby suggests that the inhalation of a gram of 'typical reactor-grade plutonium' would result in 'about 20,000 extra deaths' in a population. Barnaby adds, for the sake of visualising the quantities involved, that 'a spherical piece of plutonium oxide containing 1 gram of plutonium has a diameter of 5.5 millimetres (0.22 inch)' (Barnaby, 2000). These remarks, if proved, put nuclear proponents' claims about the relative volumes and hazards of radioactive waste into quite a different perspective: if a substance is sufficiently radioactive, then even a fraction of a 'soccer field' could represent a significant addition to levels of radiological hazard (ANSTO, 2005, p.[11]).

Reprocessing

Nuclear opponents' attention to plutonium inevitably leads to discussion of spent fuel re-processing. As discussed, the primary objective of this is to separate plutonium-rich (more radioactive) material from the other components of spent nuclear fuel, with two stated objectives: to minimise the physical quantity of the most problematic category of radioactive waste (HLW),

[3] Neutron capture is discussed in (Uranium Information Centre, 2005a; Wikipedia, 2006).

and to generate new supplies of fissile material, in the form of plutonium, as a further source of fuel for nuclear power plants. In the service of the second — somewhat contentious — objective, so-called Fast Breeder Reactors have been employed in the past, specifically designed to create higher outputs of plutonium. Historically, there have been some hopes that this could be a self-sustaining and contained process with little HLW produced as such for, as already mentioned, in this model plutonium is not considered 'waste' and, instead, becomes 'fuel' (Uranium Information Centre, 2005b, p.21).

However, reprocessing has itself been a bone of contention between nuclear proponents and opponents. Voices speaking for the negative case hold that reprocessing does not achieve what it sets out to do. The separation of plutonium from other materials, and the production of further plutonium, are seen as increasing, rather than reducing, levels of hazard, due to inherent difficulties in successfully storing and securing this most radioactive and unstable material. This is especially the case in view of its strategic importance — since plutonium is used to make nuclear weapons. From this side of the debate, the problematic aspects of reprocessing — the dangers posed by handling and processing this type of material — are underscored by the environmental record of re-processing plants at La Hague in France and Sellafield in the UK which, it is asserted, are

> by far the single most polluting nuclear facilities in the EU. Their radioactive emissions under normal operating conditions correspond to a major accident every year (Schneider and Froggatt, 2004, p.18).

This forms a strong contrast with nuclear proponents' account of the same situation, which describes how:

> A small proportion of low-level liquid wastes from reprocessing plants are discharged to the sea ... However, such discharges are regulated and controlled, and the maximum dose anyone would receive from them is a small fraction of natural background (Uranium Information Centre, 2005b, p.42).

In terms of plutonium being used as fuel, opponents argue that this is a case of diminishing returns, because MOX reactors, too, inevitably produce further plutonium as the result of neutron capture in uranium within the reactor core, resulting in a substantial, progressively growing inventory of a dangerous material for which there are few assured avenues for management (Barnaby, 2000).

The view, on this side of the debate, is that proponents' support for a model based on plutonium reprocessing and re-use is largely motivated by a desire for plutonium to be considered as 'fuel' rather than 'waste'. The production of plutonium from the nuclear fuel cycle has been a major embarrassment to the nuclear power industry since its inception, and this is an attempt to ameliorate negative perceptions. In short, the underlying rationale for re-processing is political rather than scientific. Meanwhile, a consensus is emerging, even among sources favourable to nuclear power, that 'once through' fuel cycles are safer and more secure than those that involve reprocessing (Ansolabehere, 2003, x).

Disposal

Speakers on this side of the debate dispute the degree to which nuclear waste problems can be considered solved and settled. Above, we noted a series of arguments that propose geological repositories as the main future avenue for radioactive waste management, beyond 'storage'. Yet those critical of the pro-industry position argue that 'no single repository exists anywhere in the world for the disposal of high-level waste from nuclear power' (Friends of the Earth, 2005, p.13).

A return to proponent sources bears this out. ANSTO's submission to HRSCIR notes that there is 'only one permanent disposal facility for Long-Lived Intermediate level radioactive waste in operation' (let alone HLW), and that being a military rather than a civilian facility.[4] Closer inspection of a table in the UIC submission shows that while a number of geological repositories are *proposed* across the world, there are none in operation. For most a starting date for construction (not the beginning of *operations*) is scheduled some decades hence (Uranium Information Centre, 2005b, pp.41-42). This means that there is little direct experience of using this approach, which is the current 'best shot' at the long-term management of radioactive waste. Proposed technologies such as transmutation — in which radioactive waste is changed by a technological process to more benign forms — are even more remote, and as such have been specifically excluded from serious consideration by such bodies as the UK Committee on Radioactive Waste Management (2005a, pp.6-7, 9).

As noted, the proposed Yucca Mountain repository in the US plays an important symbolic role in this part of the debate. Nuclear proponents see Yucca Mountain as proof that radioactive waste disposal — as distinct from storage — is a reality. The image of Yucca Mountain as a 'done deal' evidently supports this line of reasoning. Looking at the wider discussion surrounding Yucca Mountain, however, it becomes clear that while it has been the subject of some years of study into its suitability for HLW disposal — at a cost of $US 7 billion — the facility project has become subject to intense controversy. Questions have been raised over underground water movements, volcanic instability, and the falsification of scientific results (Barnaby, 2000; Edwards, 2002).[5]

Nuclear opponents, such as FoE, argue that even if the Yucca Mountain project were on a better footing — closer to implementation — there are severe limitations. A Yucca Mountain facility could store up to 70,000 tonnes of spent fuel, yet 'US reactors now operating are

4 'Although there are repositories for low level and short-lived intermediate level radioactive waste, presently only one permanent disposal facility for long-lived intermediate level radioactive waste is in operation — the Waste Isolation Pilot plant in New Mexico, USA, for long-lived transuranic wastes from the US military programs', (ANSTO, 2006).

5 'The US department of Energy has so far spent about $7,000 million assessing the properties of arid terrain for its use as a deep repository …The size of these resources is indicative of the scale of the problems to solved in finding a suitable way of permanently disposing of HLW.' (Barnaby, 2000). On 'falsification', see (New Scientist, "60 Seconds", 2005), and (New Scientist, "Grapevine", 2002).

expected to generate 105,000 tonnes over their lifetime' (Friends of the Earth, 2005, p.13). In a scenario where global energy demands were to be met by a three-fold increase in overall nuclear capacity, this would require new repositories of equivalent scale to Yucca Mountain 'every three or four years' across the world, and every 12 years in the US itself' — a scenario that is difficult to see as a practicable solution (Friends of the Earth, 2005, p.13).

Correspondences

While we might expect nuclear proponents to present a united front on this — one of the key questions in the nuclear policy debate — affirmative voices in the press, in fact, adopt a range of positions on the question of radioactive waste. A number of sources echo the approach adopted by ANSTO and the UIC — that is, to describe radioactive waste in such a way as to make it seem less of a problem. In many cases, the ability to handle radioactive waste with some degree of safety is assumed rather than proven:

> Opposition to nuclear power makes little sense when we have the capacity to safely dispose of the waste (Lane, 2005)

Other, even more optimistic sentiment on our ability to manage radioactive waste suggests that Australia should, as a contributor to the nuclear fuel cycle, manage not only its own waste, but that of its customers, arguing that this is, in fact, 'a moral obligation' (Wilson, 2005). This argument was given further exposure in the press with discussion of so-called 'lease-back' agreements — proposed by the US — in which the providing nation would lease rather than sell fresh nuclear fuel, and then accept it again at the end of its productive life (Lewis, 2006).[6] The intention is to prevent unauthorised military uses of uranium, but lease-back was considered 'far-fetched' and 'unsaleable' in terms of domestic political realities (Grattan, 2006), and was soon repudiated by the Prime Minister (Gordon, 2006). Nevertheless, the suggestion shows something of the imaginable dimensions of Australia's involvement in radioactive waste management, given certain settings and scenarios.

More sober views, even those offering 'affirmative' arguments, acknowledge the significance of radioactive waste as an issue, and the challenges associated with it. Rod Cameron, ANSTO Chief of Operations, suggested that 'whatever spin we put on it, it's still a very difficult issue for the industry' (Bromby, 2005). Other sources refer to radioactive waste as the industry's 'Achilles heel' (Editorial, 2005). The fundamental link between the use of nuclear materials and the need to manage radioactive waste was further underscored by one writer's suggestion that 'the nuclear industry's renaissance' would 'fizzle without a waste repository' (Huck, 2006). All of these statements show that there is a clear, shared appreciation that an expansion in Australia's nuclear activities raises difficult questions about waste, and that the more optimistic views expressed in some affirmative arguments are not representative across the board.

[6] 'Lease-back' proposals are designed to overcome obstacles to the sale of uranium to nations which are not signatories to non-proliferation agreements.

While this style of nuclear proponent either denies or minimizes the problem of radioactive waste, or looks to technological solutions for it (CSIRO, 2005, p.9), those arguing the negative case put forward a starker, simpler point of view: that we are not at all close to finding a solution to the problem of radioactive waste. These opinions are voiced by members of the federal opposition: not only from Peter Garrett, whose Green affiliations would lead us to expect such a position (Garrett, 2005), but also from the mainstream party leadership (Murphy, 2005). A few press stories also underline the infancy of the regime for high-level waste management world-wide (Minchin, 2005), thus offering some corrective to coverage that can at times be quite misleading as to the state of play in this regard (Kemeny, 2005).

Conclusion

Clearly, these are issues of key importance. The nuclear industry's claims as to the sustainability of a large-scale expansion in nuclear power generation are predicated on the idea that wastes can be managed. Even for the affirmative case, there is a range of views, from arguments that facilities are already in place, proven and tested, to those which acknowledge that radioactive waste is a sticking point in moves to increase Australia's nuclear activities.

It is possible that much of the present 'haste' evident in relation to nuclear expansion, from the most optimistic part of the affirmative case, may be driven by a desire to avoid a direct confrontation with this difficult issue. Indeed, some of the variables appear to be difficult to keep in mind — particularly the movement of ground-water — that is: to model correctly, and to factor into decision-making processes. Certainly, this does appear to be the case if some recent statements about tracing ground-water movement for the Yucca Mountain project, and proposed sites for the National Radioactive Waste Facility, are to be believed (New Scientist, "60 Seconds", 2005; New Scientist, "Grapevine", 2002; Barker, 2005; Salleh, 2005a; Salleh, 2005b).

It is open to nuclear opponents to argue that while a number of nations are working toward disposal solutions for nuclear waste, these are in a state of infancy. Placing too much reliance on these, and ramping up nuclear activities accordingly, would seem to be a high-stakes gamble, particularly in view of the longevity of resulting radiological hazards: measured, for the most active types of waste, in hundreds of thousands of years (MAPW, 2005, p.15). Opponents have argued that management under these conditions represents an unprecedented challenge, raising doubts as to whether even a single civilisation could persist for a sufficient time to see it through.

Overall, the prognosis on our capacity to manage radioactive waste is uncertain. If disposal mechanisms are not in place as claimed, then they cannot be considered to be fully tested. Even if working examples *were* in place, it would require some time to satisfy expectations of hard evidence gathered over a reasonable period. Clearly, this is important in relation to the safety and effectiveness of proposed disposal regimes. In addition, the absence of such evidence must reduce our ability to cost this part of the nuclear cycle with any degree of certainty — important in view of the questions over cost effectiveness of nuclear power discussed in the previous paper. Taken together, the evidence — or rather, lack of evidence — would seem sufficient to raise questions over the more optimistic scenarios, proposed by nuclear proponents, which describe rates of adoption for nuclear power rising at an exponential rate. The deduction may be drawn that nuclear proponents 'have a case to answer' on radioactive waste management, and that the public should expect better answers than those advanced so far.

At this stage, there are instances that can be used to support either case: in favour of the liberalisation of nuclear activities, or against. The affirmative case can indicate the example of Sweden, which appears to be the most advanced of any country in establishing a disposal capacity for radioactive waste — in caves, amidst a certain kind of rock, using particular containers, and clay, to enclose waste from its domestic nuclear power program (Holmes, 2005). Nevertheless, this disposal 'solution' is still at a 'laboratory' stage, and is not yet 'in production'. On the other hand, there are a number of well-documented accounts of problems encountered with contemporary nuclear waste sites to hand, which could support arguments for the negative case. These tell of problems in simply finding sufficient capacity to store radioactive waste in England — whether it be for Low or High-Level Waste — and of breaches at the Champagne storage facility in France, where it is alleged that plumes of radioactive material have been detected in groundwater under the site — until now a showpiece for nuclear proponents (Committee on Radioactive Waste Management, 2005b, p.7; Greenpeace, 2006; Uranium Information Centre, 2005c). Australia could face similar problems in the future — or add to its customers' problems — if it chooses to liberalise nuclear policy without due consideration for potential consequences.

References

Ansolabehere, Stephen. “The Future of Nuclear Power - Summary Report”. 2003. MIT. 01/11/05. http://web.mit.edu/nuclearpower/pdf/nuclearpower-summary.pdf

Australian Nuclear Science and Technology Organisation (ANSTO). “Submission by ANSTO to Inquiry on Non-Fossil Fuel Energy by House of Representatives Standing Committee on Industry and Resources”. 2005. Australian Nuclear Science and Technology Organisation. 13/10/05. http://www.aph.gov.au/house/committee/isr/uranium/subs/sub29.pdf

Barker, Anne. “Farmer Finds Backyard a Proposed Nuclear Dump Site”. 2005. (Thursday, 4 August , 2005 08:20:00): ABC AM program. 13/10/05. http://www.abc.net.au/am/content/2005/s1429972.htm

Barnaby, Frank. “The Management of Radioactive Wastes and the Disposal of Plutonium”. 2000. Medical Association for Prevention of War (Australia). 12/10/05. http://www.mapw.org.au/conferences/mapw2000/papers/barnaby.html

Bromby, Robin. “Nuclear Bombs out in Short-Term Reaction”. 2005. (09/06/05): The Australian. 15/06/06. http://search.epnet.com/login.aspx?direct=true&db=anh&an=200506091028918629

Committee on Radioactive Waste Management. “Report on Phase 2 of Our Work Programme”. 2005a. 02/02/06. http://www.corwm.org.uk/PDF/1210%20-%20Phase%202%20report%20July%202005.pdf

—"CORWM'S Radioactive Waste and Materials Inventory, July 2005". 2005b. 30/01/06. http://www.corwm.org.uk/pdf/1279%20-%20Task%20088%20CoRWM%20Inv%20July%202005%20Final.pdf

Commonwealth Scientific and Industrial Research Organisation (CSIRO). “Developing Australia’s Non-Fossil Fuel Energy Industry”. 2005. Commonwealth Scientific and Industrial Research Organisation. 13/10/05. http://www.aph.gov.au/house/committee/isr/uranium/subs/sub37.pdf

Department of Education, Science and Training, ‘Australia and Radiation’, accessed 16/05/06, http://www.radioactivewaste.gov.au/australia_and_radiation/categories_of_radioactive_waste.htm

Editorial. “Back to the Future with the Nuclear Energy Debate”. 2005. (19/06/05): The Sunday Age (Melbourne). 15/06/06. http://search.epnet.com/login.aspx?direct=true&db=anh&an=SYD-54V7AL7MM8KHE6175ET

Edwards, Rob. “Nuclear Waste Decision Provokes Storm of Protest”. 2002. New Scientist, 18 February 2002 21/07/06. http://www.newscientist.com/article.ns?id=dn1946

Friends of the Earth. “Inquiry into the Strategic Importance of Australia’s Uranium Resources”. 2005. 13/10/05. http://www.aph.gov.au/house/committee/isr/uranium/subs/sub52.pdf

Garrett, Peter. “No Nukes. It’s Not the Answer to the Greenhouse Threat”. 2005. (28/04/05): The Age (Melbourne). 15/06/06. http://search.epnet.com/login.aspx?direct=true&db=anh&an=SYD-544IKLLJHDWSZICKNMS

Gordon, Michael. “Pm Rules out Seeking Nuclear Leadership Role”. 2006. (17/05/06): The Age (Melbourne). http://search.epnet.com/login.aspx?direct=true&db=anh&an=SYD-59LUOY9JE7S1A0MHL2W9

Grattan, Michelle. “Howard’s New Wedge Will Have a Long Half-Life”. 2006. (24/05/06): The Age (Melbourne). 15/06/06. http://search.epnet.com/login.aspx?direct=true&db=anh&an=SYD-59PFTCH4Q1KI8ZMNMK3

Greenpeace. "The Nuclear Waste Crisis in France". 2006. 01/06/06. http://www.greenpeace.org/raw/content/international/press/reports/nuclear-waste-crisis-france.pdf

Holland, Ian. “Radioactive Waste and Spent Nuclear Fuel Management in Australia”. 2004. Parliamentary Library, Parliament of Australia. 11/10/05. http://www.aph.gov.au/library/pubs/online/RadioactiveWaste.htm

Holmes, Jonathan. "Who's Afraid of Nuclear Power?" 2005. (22/08/05): ABC Four Corners Program. http://www.abc.net.au/4corners/content/2005/s1443829.htm

Huck, Peter. “Nuclear Waste-Watchers Cast an Eye Down Under”. 2006. (07/05/06): The Sunday Age (Melbourne). http://search.epnet.com/login.aspx?direct=true&db=anh&an=SYD-59GP87737I0Y4SPD7NN

Kemeny, Leslie. “Players in a Safe Nuclear Tomorrow”. 2005. (17/10/05): The Australian. 15/06/06. http://search.epnet.com/login.aspx?direct=true&db=anh&an=200510171008823017

Lane, Terry. “Why Going Nuclear Is a Powerful Solution”. 2005. (12/06/05): The Sunday Age (Melbourne). 15/06/06. http://search.epnet.com/login.aspx?direct=true&db=anh&an=SYD-54RM63L0RE81L22YEBRS

Lewis, Steve. “Pm Wants in on N-Pact”. 2006. (13/05/06): The Australian. http://search.epnet.com/login.aspx?direct=true&db=anh&an=200605132007137972

Lloyd, Brian. “The National Radioactive Waste Facility”. 2006. Northern Territory Library. http://www.dcdsca.nt.gov.au/dcdsca/intranet.nsf/pages/ntl_parl_researchpapers

Medical Association for the Prevention of War (MAPW). “Case Study: The Strategic Importance of Australia’s Uranium Resources”. 2005. 13/10/05. http://www.aph.gov.au/house/committee/isr/uranium/subs/sub30.pdf

Minchin, Liz. “Clean, Green and Nuclear?” 2005. (28/02/2005): The Age (Melbourne). 15/06/06. http://search.epnet.com/login.aspx?direct=true&db=anh&an=SYD-53A6ZFQZSXG88LGNHV5

Murphy, Katharine. “Alp Will Allow for Uranium Growth”. 2005. (18/10/05): The Australian. http://search.epnet.com/login.aspx?direct=true&db=anh&an=200510181002694513

New Scientist, “Grapevine”, vol. 174, no. 2349 (2002).

— “60 Seconds”, vol.185, no.2492 (2005).

Salleh, Anna. “Nuclear Dump Site Gets Thumbs Down”. 2005a. (Monday, 25 July 2005): ABC Science Online. 13/10/05. http://www.abc.net.au/science/news/enviro/EnviroRepublish_1420466.htm

— “Shifting Rivers Cast Doubt on Nuclear Dump”. 2005b. ABC Science Online. 13/10/05. http://www.abc.net.au/science/news/enviro/EnviroRepublish_1425755.htm

Schneider, Mycle, and Antony Froggatt. “The World Nuclear Industry Status Report 2004”. 2004. Greens-EFA Group in the European Parliament. 09/09/05. http://www.greens-efa.org/cms/topics/dokbin/102/102943.the_world_nuclear_industry_status_report@en.pdf

Uranium Information Centre. “Plutonium - Nuclear Issues Briefing Paper No.18”. 2005a. 24/07/06. http://www.uic.com.au/nip18.htm

— “The Strategic Importance of Australia’s Uranium Resources”. 2005b. 13/10/05. http://www.aph.gov.au/house/committee/isr/uranium/subs/sub12.pdf

— Uranium Information Centre. "Radioactive Waste Repository & Store for Australia". 2005c. 21/09/06. http://www.uic.com.au/nip55.htm

Wikipedia. “Plutonium 239”. 2006. (18/07/06). 24/07/06. http://en.wikipedia.org/wiki/Plutonium-239

Wilson, Nigel. “`We Should Take Nuke Waste’”. 2005. (24/09/05): The Australian. http://search.epnet.com/login.aspx?direct=true&db=anh&an=200509241002591314