# SPENT NUCLEAR FUEL:
# REPROCESSING & REPOSITORIES

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# 1. INTRODUCTION

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Radioactive wastes are generated across the nuclear fuel cycle:
* Uranium mines typically generate large volumes of long-lived, low-level waste which is kept on site. For example the Roxby Downs copper/uranium mine in South Australia has a radioactive tailings stockpile of about 70 million tonnes, growing at 10 million tonnes annually.
* Enrichment plants generate large volumes of depleted uranium waste. (Makhijani and Smith, 2005)
* Reactors and other nuclear fuel cycle facilities discharge radioactive emissions to air and water.
* Reprocessing plants generate a high-level radioactive waste stream, in addition to the uranium and (weapons-useable) plutonium separated from spent nuclear fuel.

This paper focusses on spent nuclear fuel:
* There is a perceived need to do something about growing spent fuel stockpiles at reactor sites (not least to retain or obtain reactor operating licences).
* No repositories exist for permanent disposal of spent fuel or high-level waste, and the most advanced project, Yucca Mountain in the United States, has been a fiasco.
* Because of perceived problems with on-site storage, and the absence of disposal options, many nuclear utilities send spent fuel to commercial reprocessing plants, which act as long-term, *de facto* storage sites.
* Eventually the spent fuel must be reprocessed, which brings with it proliferation, public health and environmental risks.
* Reprocessing has led to a large and growing stockpile of unirradiated plutonium (i.e. separated plutonium plus plutonium contained in fresh reactor fuel), which is an unacceptable proliferation risk.
* Reprocessing creates the 'need' to develop MOX or fast neutron reactors to make use of the plutonium separated by reprocessing.
* All of the above necessitates a global pattern of transportation of spent fuel, high-level nuclear waste, separated plutonium and MOX, with the attendant risks of accidents, terrorist strikes, and theft leading to the production of nuclear weapons.

None of this is logical or justifiable on non-proliferation, environmental, public health or economic grounds but it suits the short-term political and commercial objectives of those involved. In other words, spent nuclear fuel management is like the old woman who swallowed a fly – every solution is worse than the problem it was supposed to solve.

The least problematic of the current options for spent fuel management is storage at reactor sites.

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# 2. SPENT NUCLEAR FUEL

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A typical power reactor (1000 MWe, light water type) produces 25-30 tonnes of spent nuclear fuel annually. About 12,000 to 14,000 tonnes of spent fuel are produced by power reactors around the world each year. Over 250,000 tonnes of spent fuel have been produced in power reactors around the world, about one third of which has been reprocessed.

These are small amounts of waste compared to the mass or volume of (gaseous) wastes generated by coal-fired electricity plants. However, there are very large waste streams generated across the nuclear fuel cycle, not least hundreds of millions of tonnes of uranium mine tailings wastes. More importantly, it is not the volume or mass of spent fuel that is of concern but its extreme toxicity, longevity, heat generation, and the fact that it contains plutonium which can be extracted for use in nuclear weapons.

The following approaches are being pursued in relation to spent fuel management (Hore-Lacey, 2003, ch.5):
* Reprocessing followed by vitrification of high-level reprocessing wastes with a view to eventual deep underground disposal. This is the policy in the UK, France, Japan, China, and India. (German nuclear utilities no longer send spent fuel to France or the UK for reprocessing from mid-2005.)
* Treating spent fuel as high-level waste with a view to eventual direct disposal. This is the policy in the US, Canada, and Sweden. (The US intends to recommence reprocessing.)
* A number of countries operating nuclear power plants have yet to choose between reprocessing, direct disposal or long-term storage.

Technologies exist to encapsulate/immobilise radionuclides to a greater or lesser degree, but encapsulated nuclear waste still represents a potential public health and environmental threat for millennia. Synroc – the ceramic immobilisation technology developed in Australia – seems destined to be a permanently 'promising' technology. As nuclear advocate Leslie Kemeny (2005) notes, Synroc "showed great early promise but so far its international marketing and commercialisation agendas have failed".

A range of alternative technologies (e.g. transmutation) or options (e.g. sea-bed disposal) have been discussed for decades. However, all are seen to be non-starters for economic, technological or political reasons. Hence the 'international consensus' on the wisdom of placing high-level waste in deep underground repositories.

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# 3. TRANSMUTATION

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Transmutation is a technological 'solution' sometimes proposed to deal with high-level, long-lived waste. The aim is to use beams of neutrons (from conventional or fast neutron reactors) or charged particles (from particle accelerators) to transform long-lived radionuclides into shorter-lived or stable isotopes. For example, neutron bombardment of radioactive iodine-129 results (indirectly) in its conversion to stable, non-radioactive xenon. And neutron bombardment of plutonium and neptunium leads to their fission which converts them into shorter-lived radionuclides.

Problems with transmutation include the following (Zerriffi and Makhijani, 2000; Makhijani et al., 2001; Ansolabehere et al., 2003; Gibson, 1991):
* The technology is still immature and its future is uncertain.
* It is useful only for certain types and forms of waste. It does not do away with the need for long-term management (storage or disposal) of the resulting wastes.
* It may require the use of reactors (with the attendant proliferation, public health and environmental risks).
* It requires reprocessing (with the attendant proliferation, public health and environmental risks) to separate ('partition') waste streams prior to selective treatment. Failure to separate/partition can lead to unwanted outcomes such as conversion of stable elements into radioactive elements.

A report from the UK's government's Radioactive Waste Management Advisory Committee (2003) concluded that partitioning and transmutation could deal with only a small fraction of the UK's higher-activity wastes, it would be costly, and would require new nuclear reactors and reprocessing plants.

The Massachusetts Institute of Technology Interdisciplinary Study concludes that: "Decisions about partitioning and transmutation must ... consider the incremental economic costs and safety, environmental, and proliferation risks of introducing the additional fuel cycle stages and facilities necessary for the task. These activities will be a source of additional risk to those working in the plants, as well as the general public, and will also generate considerable volumes of non-high-level waste contaminated with significant quantities of transuranics. Much of this waste, because of its long toxic lifetime, will ultimately need to be disposed of in high-level waste repositories. Moreover, even the most economical partitioning and transmutation schemes are likely to add significantly to the cost of the once-through fuel cycle." (Ansolabehere et al., 2003.)

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# 4. REPOSITORIES

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Not a single repository exists anywhere in the world for the disposal of high-level waste from nuclear power reactors. Only a few countries have identified a repository site. Plans are being advanced in several countries to build deep underground repositories for high-level waste, but as IAEA Director-General Mohamed El Baradei (2000, 2003) notes, these plans face significant obstacles: lack of public acceptance; cost; lack of expertise; and lack of suitable sites.

Deep repositories are promoted as final disposal sites and contrasted with storage or other options which require ongoing vigilance for long periods into the future. However there is some movement within the nuclear industry towards accepting the need for monitoring and 'retrievability' of radioactive waste in case of leaks and other problems.

Partly driven by the failure to establish national repositories, there has been growing interest in attempting to establish multinational/international repositories. However, there is also acknowledgement that multinational repositories could generate more intense public opposition than national repositories, e.g. the fierce opposition to Pangea Resources in Australia. Russia may accept foreign-origin high-level waste for disposal, and the UK may dispose of some wastes previously destined for return to their country of origin.

Some of the recurring themes are taken up by Steve Kidd (2004), head of Strategy & Research at the World Nuclear Association:

> "So what can the industry do in the future to get out of this mess? I would say four things. Number one, don't be afraid to say that you don't know whether spent fuel will be an asset or liability, as you can't be certain what future nuclear fuel markets will look like or how technology will shift. Try to sell the idea of long-term surface storage to the public on the basis that you are passing a potential asset onto the next generation, not a certain liability. Secondly, continue to investigate and demonstrate the technical merit of deep repositories as, whatever occurs, some of these are going to be needed in the future. Thirdly, look positively at the concept of international repositories. There are significant regulatory (and perhaps public acceptability) problems with these, but the idea of each nuclear country having its own looks ludicrous from several angles. Finally, actively pursue research in improved reprocessing technology, which should take place at a limited number of safeguarded sites around the world (as has also been suggested for enrichment facilities)."

The US, Sweden and Finland are said to be the most advanced countries in relation to high-level waste disposal, and these countries are discussed immediately below. In short:

* The US Yucca Mountain project is the most advanced, but it has been a fiasco.
* Sweden has yet to decide on a location for a permanent repository.

* Finland will shortly begin studies on a site which may or may not prove to be suitable for a permanent repository.

Yucca Mountain

The Yucca Mountain saga begins with the 1982 Nuclear Waste Policy Act which required the US government to take possession of spent fuel from nuclear power utilities by 1998. In 1987, legislation was passed directing the government to focus on one disposal site only – Yucca Mountain in Nevada. The 1998 deadline came and went without the goverment taking possession of any spent fuel, though a milestone was reached in 2002 when Congress approved the Yucca Mountain project.

The proposed repository still faces significant legal and political obstacles. The current timetable has a licence application being submitted in 3-4 years from now and the repository operating and accepting waste by 2017 – though the US government concedes that 2017 is a best-case scenario.

The current stockpile of waste destined for Yucca exceeds 50,000 tons, growing at 2,000 tons annually, yet the legal limit for Yucca is 70,000 tons. So it is likely that the stockpile will exceed the legal limit by the time Yucca is operational. There is currently a push to increase the legal limit in addition to some far-fetched plans (discussed later) to use novel reprocessing methods and fast neutron reactor transmutation to reduce the volume of high-level waste requiring deep geological disposal.

There is an ongoing debate about whether on-site storage at reactor sites should be expanded, or if spent fuel should be sent for interim, above-ground storage at Yucca Mountain, or whether interim stores should be established elsewhere.

The Yucca Mountain project has about 2,000 employees, and costs so far have amounted to US$8-10 billion.

Because it failed to meet the 1998 deadline, the federal Department of Energy (DOE) has had to pay US$150 million in damages to nuclear utilities. The DOE estimates that these financial penalties will rise to about $5 billion before Yucca Mountain is operational, while US nuclear industry bodies estimate that the penalties could rise to US$50 billion.

Waste problems threaten to jeopardise licensing of new reactors in the US, and the DOE's response is to lobby to have waste management excluded from reactor licensing considerations. The US House Energy and Water Development Appropriations Committee (2006) argues that attempting to "legislate away" the waste problem is not a responsible course of action.

In March 2005, a scandal emerged involving the falsification of safety data between 1998 and 2000, in relation to groundwater modeling. Evidence of the falsification of data was found in emails, and now the DOE is trawling through 14 million emails to see if it can uncover further problems.

Modeling found that Yucca Mountain could not meet the existing radiation protection standards in the long term. So the US Environmental Protection Agency attempted to set a 10,000 year limit on the application of regulatory standards, but in 2004 a federal court rejected that approach and insisted that exposure limits be set beyond 10,000 years. The EPA is currently trying to weaken the standards.

A March 2006 report by the US Government Accountability Office sums up the current status of the Yucca Mountain saga: "DOE's Yucca Mountain project has been wrestling with quality assurance problems for a long time. Now, after more than 20 years of project work, DOE is again faced with substantial quality assurance and other challenges to submit a fully defensible license application to NRC. Unless these challenges are effectively addressed, further delays on the project are likely. Furthermore, even as DOE faces new quality assurance challenges, it cannot be certain it has resolved past problems ..."

To mention just one of the many quality control problems noted by the Government Accountability Office (2006), in 1998 the DOE evaluated the models it had been using to simulate environmental conditions at Yucca Mountain and determined that 87% of the models did not comply with the validation requirements.

The Massachusetts Institute of Technology Interdisciplinary Study into the future of nuclear power notes that if global nuclear output was increased almost three-fold to 1000 GWe, and assuming direct disposal rather than reprocessing, new repository storage capacity equal to the legal limit established for Yucca Mountain would have to be created somewhere in the world "roughly every three or four years". With a ten-fold increase in nuclear power, new repository storage capacity equal to the legal limit for Yucca Mountain would have to be created somewhere in the world every single year. The US itself would need additional new capacity of the scale of Yucca Mountain about every 12 years if nuclear output was trebled. (Ansolabehere et al., 2003.)

For more information on Yucca Mountain, see:
* US Government Accountability Office, "Yucca Mountain: Quality Assurance Needs Increased Management Attention", March 2006, <http://www.gao.gov/htext/d06313.html>
* US government Department of Energy: Yucca Mountain project: <www.ymp.gov>
* State of Nevada: <www.state.nv.us/nucwaste>

Finland

In Finland, spent fuel is stored at reactor sites. Work is proceeding on what is described as a an "underground research facility" at Olkiluoto and it is hoped that this site will prove suitable for a permanent repository. The actual rock characterisation research is scheduled to take place from 2007-2011. If the site is found to be suitable, a separate licensing process would be required before the repository could be built. The cost of the final repository is estimated at three billion Euros.

Finland has four operating power reactors and one under construction – as such it has far less spent fuel to deal with than countries operating a much greater number of reactors such as the US, the UK, Japan, France, Russia, and South Korea.

More information: <www.posiva.fi/englanti>

Sweden

An interim repository for spent fuel has been operating since 1985 at Oskarshamn, and its 5,000 tonne capacity is being expanded to 8,000 tonnes to cater for all the spent fuel from current reactors. Two municipalities are now being considered as locations for a permanent deep geological repository for spent fuel.

More information: <www.uic.com.au/nip39.htm>

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# 5. REPROCESSING

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Introduction

Reprocessing involves dissolving spent nuclear fuel in acid and separating the unused uranium (about 96% of the mass), plutonium (1%) and high-level wastes (3%). Most commercial reprocessing takes place in the UK and France. There are smaller plants in India, Russia, and Japan, and Japan plans to begin large-scale reprocessing at the Rokkasho plant in 2007.

Over 80,000 tonnes of spent fuel from commercial power reactors have been reprocessed – about one third of all the spent fuel generated in power reactors. (Hore-Lacey, 2003, ch.5.)

Why reprocess? Proponents of reprocessing give the following justifications:
* Reducing the high-level waste volume and facilitating its management.
* 'Recycling' uranium to reduce reliance on natural reserves.
* Separating plutonium for use as nuclear fuel.
* Fissioning plutonium in the process, so it is no longer available for use in nuclear weapons.

Reducing the high-level waste volume and facilitating its management

Proponents of reprocessing argue that it reduces the volume of high-level waste to be disposed of compared to direct disposal of spent fuel. While the high-level waste volume is indeed reduced by reprocessing, the overall waste volume (including low- and intermediate-level waste) is increased.

Nor is it clear that reducing the volume of high-level waste will facilitate its disposal – which is in any event an academic argument since no repositories exist for high-level waste from power programs. The high-level waste stream from reprocessing still contains the vast majority of the radioactivity contained in the spent fuel. The toxicity of the high-level waste is more a function of its radioactivity and heat generation than its volume.

'Recycling' uranium to reduce reliance on natural reserves

This argument would only have some validity in the context of limited uranium reserves. However, as Steve Kidd (2006) from the World Nuclear Association states: "... the nuclear industry is convinced that there are more than adequate uranium reserves and resources to fuel any conceivable growth path of nuclear energy this century."

According to the IAEA (2006), known plus speculative conventional uranium reserves will suffice for about 270 years at the current rate of consumption. Therefore, uranium supply difficulties would only arise this century in the event of an improbably large expansion of nuclear power.

Only a small percentage of the uranium extracted from spent fuel via reprocessing has been recycled because it is more expensive and because uranium recovered from reprocessing contains isotopes such as uranium-232 which complicate its use and pose environmental and health risks. (Leventhal and Dolley, 1999.)

According to the IAEA (2006): "Uranium recovered through reprocessing of spent fuel, known as reprocessed uranium, is currently recycled only in France and the Russian Federation. Available data indicate that it represents less than 1% of world requirements."

Theoretically, reprocessing would lessen the amount of uranium mining with its attendant environmental impacts. Currently, we have the worst of both worlds – major reprocessing operations which do almost nothing to reduce demand from uranium mines.

Separating plutonium for use as a nuclear fuel

This is a circular argument because one of the main drivers of plutonium-fuelled reactors is simply the need to find a use for plutonium separated at reprocessing plants, thereby legitimising the existence of reprocessing plants.

Plutonium reactors are:
* MOX reactors – modified conventional reactors using mixed uranium oxide / plutonium oxide fuel.
* fast neutron reactors which do not need a moderator since 'fast' neutrons can maintain a chain reaction with plutonium fuel (fast reactors are 'breeders' or 'burners' depending on whether they produce more plutonium than they consume).

(In addition, it should be noted that some of the heat generated in conventional uranium reactors is produced by the fissioning of plutonium which is created in the reactor via irradiation of uranium-238.)

Very little plutonium is required for fast neutron reactors since very few are operating (the total worldwide experience amounts to 300 reactor-years). Some plutonium is used in MOX fuel, which accounts for 2-5% of the world's reactor fuel usage. (Parliamentary Office of Science and Technology, 2005; Repáraz, 2003.)

MOX has no advantages over conventional uranium fuel. In fact it is more hazardous and more expensive (Repáraz, 2003). Further, several comparative economic studies – comparing the total fuel cycle costs of a reprocessing-recycling system and an open fuel cycle with direct disposal – have shown the reprocessing-recycle option to be the most costly. (Berkhout, 1997.)

For some years the privatised nuclear power utility British Energy fought to have its reprocessing contracts cancelled, citing the increased costs associated with reprocessing. Michael Kirwan, British Energy's finance director, said: "As far as we are concerned, reprocessing is an economic nonsense and should stop straight away." (WISE, 2000.)

MOX also poses proliferation risks because it requires the separation of plutonium and the transportation of nuclear materials, and because separating plutonium from MOX is far simpler and safer than extracting it from spent fuel.

The IAEA (1997) states that the quantity of separated plutonium would be higher were it not for its use in MOX fuel and in a few fast neutron reactors. That disingenuous statement ignores the fact that the use of plutonium is a major rationale for reprocessing in the first place. Further, the consumption of plutonium in MOX reactors is modest (because consumption is partly off-set by plutonium production from uranium-238). MOX is regarded as a stepping stone toward the commercial use of fast neutron reactors with the potential to create more plutonium than they consume (i.e. breeders). For these and other reasons, MOX (and fast neutron reactors) are part of the plutonium problem not the solution. (Leventhal and Dolley, 1999; 1999B; Repáraz, 2003.)

<u>Proliferation and reprocessing</u>

Potentially, reprocessing and using the plutonium as nuclear fuel could reduce proliferation risks by destroying some or all of the plutonium. In reality, proliferation risks are significantly increased by reprocessing.

The production of vast amounts of plutonium in power reactors – over 1,600 tonnes to date, enough for about 160,000 weapons – is problem enough, but the problem is greatly exacerbated by the separation of plutonium in reprocessing plants. Whereas separation of plutonium from spent fuel requires a reprocessing capability and is potentially hazardous because of the radioactivity of spent fuel, the use of separated plutonium for weapons production is far less complicated.

The separation of plutonium exceeds its use in MOX and fast neutron reactors. According to the Uranium Information Centre (2002), only about one third of separated plutonium has been used in MOX over the last 30 years. Thus the stockpile of separated plutonium continues to grow – about 15-20 tonnes of plutonium are separated from spent fuel each year but only 10-15 tonnes are fabricated into MOX fuel. (Albright and Kramer, 2004.)

The IAEA stated in 1997 that plutonium stocks should decrease modestly after 1999 (IAEA, 1997; Oi, 1998). However, the stockpiles continue to grow and there is no longer any serious expectation that the use of plutonium in MOX or fast neutron reactors will 'catch up' to plutonium separation in the near future.

The stockpile of plutonium in unirradiated forms – i.e. separated or in plutonium reactor fuel (primarily MOX) – currently amounts to about 270 tonnes (Greenpeace, 2005). The largest 'civil' plutonium stockpiles are in the UK, France and Russia. In addition to stockpiles held by commercial reprocessors (primarily the UK and France), some of the plutonium separated in reprocessing plants has been returned to customer countries (either as separated plutonium or in fuel). This raises further proliferation concerns. The countries with holdings of separated 'civil' plutonium are: Belgium, Germany, India, Italy, Japan, the Netherlands, Russia, Spain, Sweden, Switzerland, the UK, and the US (Institute for Science and International Security, n.d.)

Addressing the problem of growing stockpiles of unirradiated plutonium could hardly be simpler – it only requires that reprocessing be slowed, suspended, or stopped altogether.

The nuclear industry makes much of the potential to use MOX or fast neutron reactors to 'burn' plutonium. However, these reactors – especially fast neutron reactors – can be configured to produce more plutonium than they produce. Moreover, while in the short term plutonium stockpiles could potentially be reduced through the use of MOX or fast neutron reactors, in the longer term they depend on an ongoing supply of plutonium.

<u>Environmental and public health impacts of reprocessing</u>

Reprocessing separates spent fuel into different streams – it does nothing to reduce the toxicity or radioactivity of the waste.

Civil reprocessing releases significant quantities of radioactive wastes into the sea and gaseous discharges into the air. Cogema's reprocessing plant at La Hague in France, and the reprocessing plant at Sellafield in the UK, are the largest source of radioactive pollution in the European environment (WISE-Paris, 2001). The radioactive contamination from these facilities can be traced through the Irish Sea, the North Sea, along the Norwegian coast into the Arctic and Atlantic Oceans, and gives rise to elevated contamination levels in biota. There is an increase in the rate of childhood leukaemia and other radiation-linked diseases in the vicinity of both Sellafield and La Hague although the link between the reprocessing plants and these increases is contested.

Kidd (2004) from the World Nuclear Association states: "It is true that the current Purex reprocessing technology is less than satisfactory. Environmentally dirty, it produces significant quantities of lower level wastes." (Purex is used at Sellafield and La Hague.)

The OSPAR Commission regulates marine pollution in the North-East Atlantic under the terms of the 1992 OSPAR Convention (<www.ospar.org>). Fifteen European countries are parties to the Convention, as is the European Union. Most of the European countries party to the Convention have been calling for a sharp reduction in radioactive emissions from Sellafield and La Hague.

At the Ministerial-level OSPAR meeting in 1998, all parties agreed to progressive and substantial reductions in radioactive discharges to achieve by the year 2020 close to zero concentrations in the marine environment above historic levels.

At the 2000 OSPAR meeting, a resolution was passed stating that: "The current authorisations for discharges or releases of radioactive substances from nuclear reprocessing facilities shall be reviewed as a matter of priority by their competent national authorities with a view to, inter alia, implementing the non-reprocessing option (for example, dry storage) for spent nuclear fuel management at appropriate facilities." (OSPAR, 2000.)

The 2000 OSPAR resolution was supported by 12 countries – Denmark, Belgium, Finland, Germany, Norway, The Netherlands, Switzerland, Portugal, Spain, Sweden, Iceland, and Ireland – but not by France or the UK.

The hazards associated with reprocessing were highlighted in April 2005 with the revelation of an accident at the THORP reprocessing plant at Sellafield in the UK. A broken pipe led to the leaking into a containment structure of 83,000 litres of nitric acid containing dissolved spent fuel. The leakage began in January 2005 at the latest, and possibly as early as August 2004. The accident was classified as category III – a 'serious incident' – on the International Nuclear Event Scale. In October 2006, British Nuclear Group (BNG) was fined £500,000 because of the accident, having pleaded guilty to three charges – failing to make and comply with written instructions, failing to ensure that safety systems were in good working order, and failing to ensure that radioactive material was contained and, if leaks occur, that they were detected and reported. In addition, the Nuclear Decommissioning Authority imposed a fine (in the form of a ‘fee reduction’) for failing to maintain 'appropriate levels of safety' at the THORP plant. Restart of the plant is set for early 2007 although there remains considerable uncertainty over the timing of the restart and the long-term viability of the THORP reprocessing plant. (CORE, 2006, 2006B)

The old woman who swallowed a fly

*There was an old woman who swallowed a cow,*
*I don't know how she swallowed a cow!*
*She swallowed the cow to catch the goat,*
*She swallowed the goat to catch the dog,*
*She swallowed the dog to catch the cat,*
*She swallowed the cat to catch the bird,*
*She swallowed the bird to catch the spider,*
*That wriggled and jiggled and tickled inside her,*
*She swallowed the spider to catch the fly,*
*I don't know why she swallowed the fly,*
*Perhaps she'll die.*

The perceived need to do something about growing spent fuel stockpiles at reactor sites (not least to maintain or obtain reactor operating licences), and the lack of repositories for permanent disposal ...
... encourages nuclear utilities to send spent fuel to commercial reprocessing plants, which act as long-term, *de facto* storage sites
... eventually the spent fuel must be reprocessed, which brings with it serious proliferation, public health and environmental risks
... reprocessing has led to a large and growing stockpile of unirradiated plutonium, which is an unacceptable proliferation risk.
... reprocessing creates the 'need' to develop MOX or fast neutron reactors to make use of the plutonium separated by reprocessing.
... and all of the above necessitates a global pattern of transportation of spent fuel, high-level waste, separated plutonium and MOX, with the attendant risks of accidents, terrorist strikes, and theft leading to the production of nuclear weapons.

None of this is logical or justifiable on non-proliferation, environmental, public health or economic grounds – industry spin notwithstanding – but it suits the short-term political and commercial objectives of those involved. In particular, reprocessing plants act as long term, *de facto* storage sites, which suits nuclear power utilities and national governments in nuclear power generating countries – they can export their high-level waste problems to reprocessing countries. Commercial interests involved in reprocessing and plutonium reactors have an obvious interest in the continuation of reprocessing policies. Commercial interests involved in nuclear power also benefit to the extent that sending spent fuel to reprocessing plants makes it easier to retain or obtain reactor operating liccences.

George Monbiot (2002) attempted to explain the logic of the British nuclear industry in *The Guardian*:

> "[British Nuclear Fuels Ltd.] must defend those markets [for MOX] in order to justify the government's decision in October to allow the MOX plant at Sellafield in Cumbria to open. The MOX plant opened in order to make sense of the reprocessing operations at Sellafield, which extract plutonium and uranium from nuclear waste. The reprocessing

> was permitted in order to provide a reason for Sellafield's continued existence. Sellafield exists in order to keep the British nuclear power programme running. The British nuclear power programme exists because – well, it exists because it exists. There may once have been a reason, but if so it has been lost in the mists of time. Britain's nuclear policy, in other words, is like the old woman who swallowed a fly. Every solution is worse than the problem it was supposed to address. Every new justification ratchets up the probability of a major nuclear accident or breach of security. Yet the programme's institutional momentum carries all before it."

US reprocessing plans

While reprocessing has been dirty, dangerous and expensive, it has an elegant theoretical rationale - extending uranium reserves, making use of the energy of plutonium and removing it as a proliferation risk in the process, and helping to address waste management problems.

The US is embarking on the Global Nuclear Energy Partnership (GNEP) which includes domestic waste plans even more elegant than conventional reprocessing – and even more likely to be unsuccessful, expensive, dirty and dangerous. In addition to the familiar aims of reprocessing, the US hopes to transmute troublesome, long-lived transuranic radionuclides into short-lived nuclides by irradiating them along with plutonium fuel. To achieve these aims, new reprocessing method/s will be required in addition to a fleet of fast neutron reactors. (US Department of Energy, n.d.; Oelrich, 2006; US House Energy and Water Development Appropriations Committee, 2006.)

Richard Lester (2006), professor of nuclear science and engineering at the Massachusetts Institute of Technology, states: "The Bush administration claims that this scheme could eliminate the need for repositories other than Yucca Mountain, cut the duration of the waste disposal problem from hundreds of thousands of years to something much shorter, and use almost all the energy in uranium fuel. This is an appealing vision, but the reality is that GNEP is unlikely to achieve these goals and will also make nuclear power less competitive."

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# 6. WHAT TO DO WITH NUCLEAR WASTE?

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A common-sense approach to radioactive waste involves the following three steps:
1. Minimising the production of radioactive waste;
2. Thoroughly assessing *all* options for the management of radioactive waste; and
3. Using scientific and environmental siting criteria rather than choosing politically 'soft' targets.

Public involvement in decision making, and informed consent to proposals, is also essential if an equitable outcome is to be achieved. Involvement and informed consent are also desirable from a practical point of view. There is a long history of communities successfully mobilising to force the abandonment of nuclear dump proposals.

Before producing radioactive waste, it needs to be demonstrated that the benefits outweigh the risks. Unfortunately, waste minimisation principles are too often honoured in the breach. For example, the plan for a new reactor at Lucas Heights was not subject to thorough, independent analysis. (Friends of the Earth, 2005.)

Much of the debate on waste management options assumes the 'need' for off-site stores or dumps. But the option of storing waste where it is produced needs serious consideration.

Even if centralised facilities exist, waste is inevitably stored at the site of production, often for long periods. On-site storage facilities must be adequately constructed and regulated whether or not centralised, off-site waste management facilities exist. With adequate on-site storage facilities, the case for centralised facilities is weakened, especially considering the progressive decline of the radioactivity and toxicity of radioactive waste.

Storage at the site of production has other advantages:
* Avoiding altogether the risks of transportation.
* It is by far the best (and perhaps the only) way to get radioactive waste producers to get serious about minimising waste production. Conversely, the provision of an out-of-sight-out-of-mind disposal option, as with the federal government's planned nuclear waste facility in the Northern Territory, is likely to lead to more profligate waste production.

In the case of the Lucas Heights research reactor plant, operated by the Australian Nuclear Science and Technology Organisation (ANSTO), it is difficult to see why ANSTO cannot continue to store its waste rather than the current push to dump it in the NT – albeit the case that improved waste management systems and greater transparency are required at ANSTO.

Australia's nuclear expertise is heavily concentrated at Lucas Heights. Conversely, there is little or no nuclear expertise in the vicinity of proposed nuclear dump sites in the NT.

All of the key proponents of the proposed nuclear waste facility in the NT have acknowledged that ANSTO can continue to manage its own waste at Lucas Heights - ANSTO, the regulator ARPANSA, and the federal Department of Education, Science and Training. (Friends of the Earth, 2006.) Moreover, ANSTO is increasing its storage capacity as a contingency in the event that the NT dump plan is delayed or abandoned. (ARPANSA Nuclear Safety Committee, 2005.)

An often-ignored aspect of decisions over waste management options is the question of *who* should have responsibility for waste management. As mentioned, there is a moral argument that waste producers should manage their own wastes rather than foisting the problem on others, all the more so since this is likely to lead to waste minimisation and to discourage profligate waste production.

Further, the competence of the relevant parties must be considered. In the case of ongoing proposals to transfer control of radioactive waste to the Department of Education, Science and Training (DEST), there has been a compelling argument not to transfer control to DEST because of the Department's track record of incompetence, deceit, secrecy and racism in relation to the 'clean up' of Maralinga in the 1990s and the 1998-2004 campaign to impose a dump on South Australia. (Friends of the Earth, 2004.)

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