Submission to the SA Nuclear Fuel Cycle Royal Commission

by Friends of the Earth, Australia; the Australian Conservation Foundation; and the Conservation Council of SA

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List of Recommendations

Recommendation 1: The Royal Commission should ask the federal government and uranium companies supplying China what they are doing about the serious problems with China's nuclear power industry (safety, security, corruption, inadequate regulation, etc.).
Recommendation 2: The Royal Commission should ask the SA government what steps have been taken to prevent a recurrence of problems such as those that arose with Marathon Resources and what regulatory and monitoring changes have been adopted in response to this situation.
Recommendation 3: The Royal Commission should determine what action if any the federal and SA governments took in response to allegations of corporate impropriety by General Atomics / Heathgate as detailed in Fortune Magazine.
Recommendation 4: The Royal Commission should recommend the enactment of legislation outlawing the infiltration of NGOs by mining companies.
Recommendation 5: The Royal Commission should recommend the enactment of legislation outlawing police infiltration of NGOs involved in peaceful protest activities.
Recommendation 6: The Royal Commission should determine the extent and adequacy of usage of protective equipment including masks at underground uranium mines (currently limited to Olympic Dam in Australia).
Recommendation 7: The Royal Commission should investigate claims made by a BHP Billiton whistleblower in 2010 that the company uses manipulated averages and distorted sampling to ensure its official figures of worker radiation exposure fall under the maximum exposure levels set by government. The Royal Commission should also investigate the claim that radiation dose estimates are based on the assumption that all workers wear a respirator when exposed to polonium dust in the smelter.
Recommendation 8: The Royal Commission should investigate why BHP Billiton's radiation plans were seriously outdated and why the SA government did not act to rectify the problem. The Royal Commission should seek further detail into what steps SA agencies have taken to address these deficiencies and enhance transparency.
Recommendation 9: The Royal Commission should investigate FoI-based claims by MLC Mark Parnell regarding polonium exposure and reporting requirements at Olympic Dam.
Recommendation 10: Uranium company representatives should explain to the Royal Commission why they have promoted self-serving contrarian views regarding radiation and health instead of promoting the accepted scientific understanding that there is no safe level of exposure to ionising radiation.
Recommendation 11: The Royal Commission should investigate the use of Doug Boreham by some uranium companies to provide 'employee radiation training'. Are Boreham and uranium companies encouraging practices at odds with established OH&S advice and recommendations?
Recommendation 12: The Royal Commission should determine whether the provision of contrarian advice at odds with mainstream scientific opinion meets the legislative and regulatory requirements for the provision of advice on radiological workplace hazards in SA.
Recommendation 13: The Royal Commission should determine whether the provision of personal protective equipment is sufficient or if there is (or should there be) a requirement for workers to actually use protective equipment?
Recommendation 14: The Royal Commission should recommend against any further uranium/nuclear developments until such time as:

- Laws exempting the uranium industry from Aboriginal heritage protection laws are repealed.
- Maralinga is cleaned up adequately.
- There have been independent inquiries into the mistreatment of Aboriginal people in relation to attempts to establish national nuclear waste facilities in SA (1998−2004) and the NT (2005−2014), and mechanisms put in place to prevent further such adverse processes and impacts.
- The use of divide and rule tactics by uranium companies against Aboriginal people is investigated and mechanisms put in place to prevent such tactics being deployed in future.
- Aboriginal land owners are afforded an effective veto provision over proposed mining and wider nuclear industry developments on their lands.

Recommendation 15: The Royal Commission should investigate the pattern of Aboriginal heritage protections and land rights legislation being weakened or overriden to facilitate the uranium industry. The Royal Commission should recommend legislative change to rectify the situation, especially the introduction of a credible veto provision to help address the current systemic power imbalance that exists between mining companies and Aboriginal landowners.
Recommendation 16: The Royal Commission should ascertain whether BHP Billiton still threatens "disciplinary action" against any worker caught taking photos of the mine site, and if such threats are consistent with world's best practice.
Recommendation 17: The Royal Commission should ask BHP Billiton why it claimed that "allegations" raised in the media in 2009 referred to a single incident involving a small damp patch on the wall of the tailings retention system, when in fact publicly-released photos clearly showed multiple leaks, and the leaks were ongoing for months.
Recommendation 18: The Royal Commission should determine whether current tailings management practices are adequate at Olympic Dam and whether the FoI-based issues reported by *The Australian* newspaper in 2006 have been rectified. This is particularly important in the context of the tailings management implications of BHP's current move towards heap leach processing.
Recommendation 19: The Royal Commission should thoroughly investigate the Roxby Downs Indenture Act and recommend far-reaching legislative change to address the Act's multiple indefensible exemptions and overrides.
Recommendation 20: The Royal Commission should investigate bird deaths at Olympic Dam and ascertain if current measures to prevent bird deaths are adequate.
Recommendation 21: The Royal Commission should investigate whether arrangements to cover rehabilitation of the Olympic Dam site are adequate.
Recommendation 22: The Royal Commission should investigate the impact of Olympic Dam's water consumption on the Mound Springs, and recommend appropriate measures to prevent further adverse effects on the Mound Springs.
Recommendation 23: The Royal Commission should investigate the environmental, economic and other impacts of mining copper, gold and silver but not uranium at Olympic Dam.
Recommendation 24: We note the long standing recognition of the threats posed by uranium mine tailings, including a Senate finding that viewed "tailings management as amongst the most serious challenges facing uranium miners and, indeed, the entire nuclear energy industry".[1] The Royal Commission should recommend that BHP Billiton should be required to meet both Australian best practice standards and world best practice standards in relation to tailings management.
Recommendation 25: The Royal Commission should recommend a thorough, independent assessment of the options for managing liquid waste from ISL mines.
Recommendation 26: The Royal Commission should recommend that ISL mines are monitored and if necessary remediated until pre-mining water quality conditions are achieved.
Recommendation 27: The Royal Commission should determine whether any follow-up work been done to investigate the potential to assist or hasten attenuation of ISL-contaminated groundwater.
Recommendation 28: The Royal Commission should ask ISL mining companies to update their projections on the viability of returning land for pastoral use post-mining, noting that the 2009 *Beverley Four Mile Project Public Environment Report and Mining Lease Proposal* document assessed a 'Moderate' risk of contamination preventing a return to pastoral use.
Recommendation 29: The Royal Commission should recommendation studies into rehabilitation options for disused uranium mines in Australia, the implementation of appropriate measures to reduce public health and environmental hazards, and the status and adequacy of funding mechanisms.
Recommendation 30: The Minerals Council of Australia should be asked to justify its fanciful figures regarding current and potential future employment by the uranium industry in Australia.

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[1] Senate Select Committee on Uranium Mining and Milling, May 1997, p.63.

Recommendation 31: The Royal Commission should determine whether BHP Billiton and other uranium miners in Australia are using artificial tax avoidance structures, estimate the economic impact of any such structures, and make recommendations accordingly.
Recommendation 32: The Royal Commission should recommend that the SA Government establishes an inquiry into the use of materials containing radioactive and nuclear substances, and consideration of alternatives that may be preferable for security, public health, and environmental reasons.
Recommendation 33: The Royal Commission should recommend that state and federal governments no longer permit uranium sales to:

- repressive, secretive countries (e.g. China and Russia − albeit the case that sales to Russia have been suspended)
- nuclear weapons states that are not fulfilling their disarmament obligations under the Nuclear Non-Proliferation Treaty (US, Russia, China, France, UK)
- countries that have not ratified the Comprehensive Test Ban Treaty (China, USA, India)
- countries with a history of weapons-related research based on their civil nuclear programs (South Korea and Taiwan).

Recommendation 34: The Royal Commission should recommend that state and federal governments prohibit high enrichment of Australian uranium and prohibit the separation and stockpiling of Australian-obligated plutonium.
Recommendation 36: The Royal Commission should recommend that state and federal governments prohibit the processing of Australian Obligated Nuclear Materials in facilities beyond the scope of IAEA safeguards.
Recommendation 37: The Royal Commission should recommend public release of country-by-country information on the separation and stockpiling of Australian-obligated plutonium; all current and future 'Administrative Arrangements' pertaining to uranium exports; detailed information on nuclear accounting discrepancies including the volumes of nuclear materials, the countries involved, and the reasons given to explain accounting discrepancies; and the quantities of Australian Obligated Nuclear Materials held in each country.
Recommendation 38: The Royal Commission should recommend that state and federal governments do not permit uranium sales to countries that have not signed the Non-Proliferation Treaty or the Comprehensive Test Ban Treaty and are actively expanding their nuclear weapons arsenals (e.g. India).
Recommendation 39: The Royal Commission should investigate the deficiencies in the process leading to the approval of uranium sales to Russia, including statements made by the Australian Safeguards and Non-proliferation Office.
Recommendation 40: The Royal Commission should recommend an independent public inquiry covering all aspects of the operation of the Australian Safeguards and Non-proliferation Office.
Recommendation 41: The Royal Commission should consider whether the national security provisions in the ARPANS Act are appropriate.
Recommendation 42: The Royal Commission should consider whether ARPANSA would be better served with a number of commissioners (along the lines of the US Nuclear Regulatory Commission) rather than a single CEO, and recommend accordingly.
Recommendation 43: The Royal Commission should investigate the circumstances that led to ANSTO's Executive Director being involved in the selection of the founding CEO of ARPANSA, and make recommendations to prevent regulated bodies playing any role whatsoever in the selection regulatory personnel.
Recommendation 44: The Royal Commission should recommend that, if plans for nuclear power or nuclear fuel cycle facilities (including waste stores or repositories) are advanced, that a world's best practice liability regime should be put in place, with no limits on the amount of compensation payable, and suppliers as well as operators held accountable.
Recommendation 45: The Royal Commission should recommend the establishment of a National Commission to thoroughly evaluate all options for managing Australia's radioactive waste.

Recommendation 46: The Royal Commission should recommend that any further discussion on accepting international waste should be put on hold until lasting solutions are implemented to safely manage Australia's radioactive waste.
Recommendation 47: The Royal Commission should recommend the establishment of an independent commission to investigate safety, security and regulatory aspects of radioactive materials transport in Australia.

Issues Paper #1: Exploration, Extraction and Milling

1.1 Are there opportunities for new or further exploration activities directed at locating new mineral deposits, or to better understand existing deposits containing economic concentrations of uranium or thorium in South Australia? What specifically are those opportunities? What might understanding those opportunities be reasonably expected to reveal? What needs to be done to understand their potential more clearly?
1.2 What are the economic conditions including those in resource markets that would be necessary for the financial viability of new exploration activities directed at locating uranium or thorium? Aside from economic conditions, how do factors such as access to investment, skills training, taxation, research and development, innovation and regulation, bear on decisions to invest in new activities? What is most important?
1.3 What might be necessary to encourage further exploration for uranium and thorium? What might be done to promote viability? Are existing government plans sufficient? Could support be provided in other ways and, if so, how could that be done most effectively? Is there a sufficient availability of information from exploration activities previously undertaken?
1.4 Are there either existing proven uranium or thorium resources which might feasibly be developed? Where are they? What specifically needs to be done to develop these? How long would the development process take?
1.5. What would be necessary to develop new mine sites or expand existing sites? To what extent are those factors affected by the ability to extract commercial resources other than uranium? What are the necessary factors that might stimulate an expansion in activity? What is the evidence that those factors have been relevant to an expansion in activities elsewhere?
1.6 Does more need to be done now and in the future with factor inputs (including skills and training, research, education and infrastructure) which are relevant to decisions made to invest in new projects or to expand those that already exist? What capabilities and capacities would be required for the development of new projects? What is the evidence that any specific deficiency influences new investment? What needs to be done to address any deficiency and how would it be done?

All of the above questions assume that an expansion of the uranium industry is desirable. The NFCRC should be questioning whether the benefits of the industry outweigh the problems and risks.

Our organisations are concerned that the NFCRC could recommend a further weakening of the already inadequate environmental standards to facilitate an expansion of uranium mining (see sections 1.10 and section 1.11 below).

At numerous points NFCRC literature references 'best practices'. The NFCRC should recommend a best-practice approach to Indigenous land rights, incorporating a right of veto as per the federal Aboriginal Land Rights Act. However if the sole aim is to promote the uranium industry it would be logical to recommend a further weakening of the SA Aboriginal Heritage Act and other relevant legislation.

If the sole aim it to promote the uranium industry it would be logical to recommend a further weakening of safeguards and a further weakening of export policy (e.g. expanding the bipartisan support of uranium sales to India to encompass all non-signatories to the Nuclear Non-Proliferation Treaty). However

safeguards need strengthening not weakening, and existing export policy (e.g. permitting uranium sales to states breaching their NPT commitments, dictatorships, states refusing to sign or ratify the Comprehensive Test Ban Treaty, etc) is already too lax.

Some context is required. Uranium accounts for a tiny percentage of Australian export revenue. In the 2011/12 financial year[2]:

- uranium accounted for 0.19% of national export revenue (the 2013/14 figure was also 0.19%[3] and the figure for 2014/15 would be very similar);
- uranium revenue was 4.4 times lower than Australia's 20th biggest export earner, wool;
- uranium revenue was 8.7 times lower than Australia's 10th biggest export earner, aluminium; and
- uranium revenue was 103 times lower than the biggest earner, iron ore.

Even if the NFCRC agreed with the uranium industry's entire wish list of weakening environmental standards, weakening safeguards and export policy, weakening Indigenous land rights and heritage protections, etc., and even if state and federal government's implemented that wish list, it is difficult to imagine uranium export revenue doubling let alone tripling. Yet even if uranium export revenue tripled, it would still fall well short of accounting for 1% of national export revenue − and still less if the high degree of foreign ownership of uranium mining companies operating in Australia is taken into account.

In 2011, the total value of global uranium requirements was approximately US$10 billion[4] − and the current figure would be very similar (with recent contract prices typically around US$50−55/lb U3O8). From 2011 to 2013, uranium was produced in 21 countries, and a 2014 UN report states that "more than 20 countries around the globe produce uranium".[5] Thus many countries are competing in a market which is modest in size.

Even using the most optimistic assumptions, uranium will remain a very small contributor to national export revenue. During the years 2002−2011, uranium's peak contribution to national export revenue was 0.45%.[6] Even with a doubling of that peak, uranium would account for less than 1% of export revenue.

The willingness of state and federal governments to invest resources into promoting the uranium industry (e.g. the federal government's Uranium Council / Uranium Industry Framework) is disproportionate to the existing and potential economic benefits. Milk and cream generate twice as much export revenue as uranium − why no Royal Commission to bolster the dairy industry?

Thorium is mentioned in questions 1.1 to 1.4. Thorium is discussed in section 3.2 of this submission. Suffice it here to note that there is no likelihood of any demand for Australian thorium in the foreseeable future so it would be an extraordinary waste of resources to attempt to kick-start an industry mining a product for which there is no demand.

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[2] ACF, 2013, 'Yellowcake Fever: exposing the uranium industry's economic myths', www.acfonline.org.au/resources/yellowcake-fever-exposing-uranium-industrys-economic-myths

[3] Uranium exports in FY 2013/14: $622m
www.world-nuclear.org/info/Country-Profiles/Countries-A-F/Australia/
Total national export revenue (goods and services) in FY 2013/14: $332 billion
www.trademinister.gov.au/releases/Pages/2014/ar_mr_140805.aspx?ministerid=3

[4] ACF, 2013, 'Yellowcake Fever: exposing the uranium industry's economic myths', section 2, 'Australia's uranium export revenue in perspective', www.acfonline.org.au/resources/yellowcake-fever-exposing-uranium-industrys-economic-myths

[5] UN News Centre, 10 Sept 2014, 'Despite price dip, uranium demand, production continues to rise – UN atomic watchdog', www.un.org/apps/news/story.asp?NewsID=48678

[6] ACF, 2013, 'Yellowcake Fever: exposing the uranium industry's economic myths', www.acfonline.org.au/resources/yellowcake-fever-exposing-uranium-industrys-economic-myths

1.7 Is there a sound basis for concluding that there will be increased demand for uranium in the medium and long term? Would that increased demand translate to investment in expanded uranium production capacity in South Australia (bearing in mind other sources of supply and the nature of South Australia's resources?)

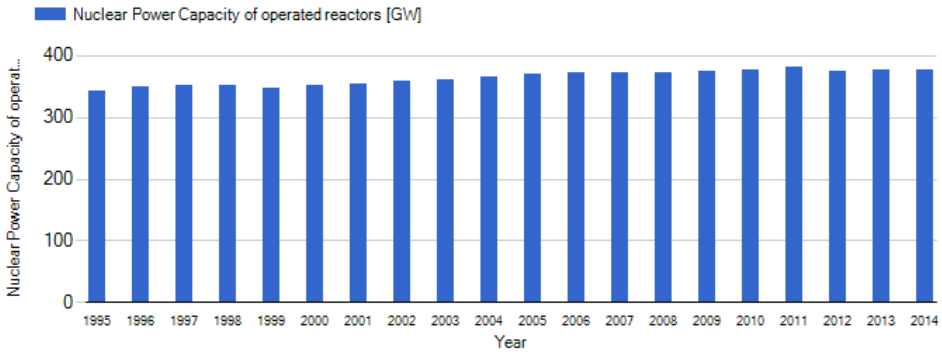
There is no sound basis for concluding that there will be any significantly increased demand for uranium in the medium and long term. Plausible projections for the next 20 years range from a modest decline in demand to a modest increase.

The following comments address:

- the status and trajectory of nuclear power;
- the global uranium industry; and
- the Australian uranium industry.

The status and trajectory of nuclear power

Despite the promotion of a nuclear power 'renaissance' over the past decade, the number of 'operable' power reactors fell from 443 to 437 from January 2005 to January 2015.[7] Global nuclear power generating capacity grew by 2.6% over the same period.[8] Nuclear capacity has been stagnant for the past two decades.



Source: IAEA, www.iaea.org/PRIS/WorldStatistics/WorldTrendNuclearPowerCapacity.aspx

Nuclear's share of electricity generation peaked at 17.6% in 1996 and now stands at 10.8%. Nuclear power generation peaked at 2,660 terrawatt-hours (TWh) in 2006 and was 9.4% lower in 2013 (2,410 TWh). These statistics are presented in the annual World Nuclear Industry Status Reports, which provide a wealth of useful information (www.worldnuclearreport.org).

The latest World Nuclear Industry Status Report was released in July 2015.[9] Notable facts raised in the latest report include the following:

- Nuclear plant construction starts fell from fifteen in 2010 to three in 2014.
- 62 reactors are under construction − five fewer than a year ago − of which at least three-quarters have been delayed.[10] In 10 of the 14 building countries all projects are delayed, often by years.

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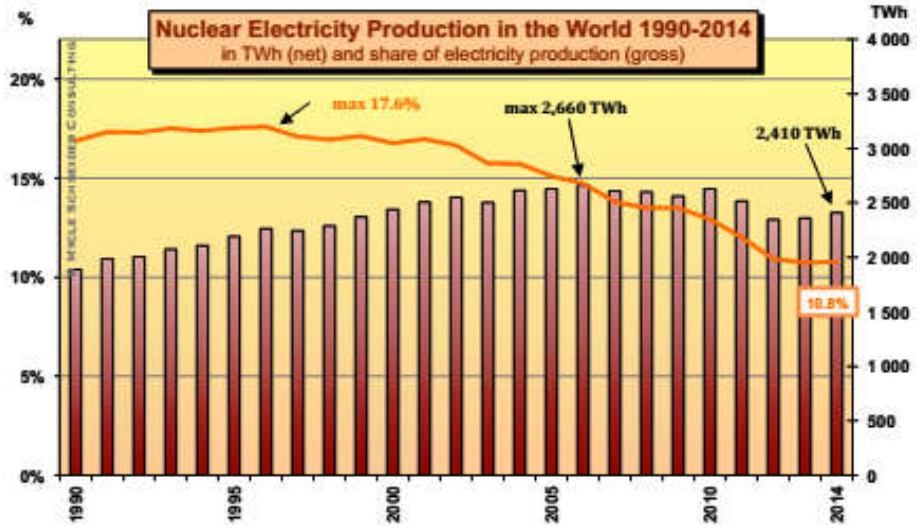
[7] Running in reverse: the world's 'nuclear power renaissance', 29 Jan 2015, www.theecologist.org/News/news_analysis/2732640/running_in_reverse_the_worlds_nuclear_power_renaissance.html
[8] IAEA, 'Nuclear Power Capacity Trend', www.iaea.org/PRIS/WorldStatistics/WorldTrendNuclearPowerCapacity.aspx
[9] World Nuclear Industry Status Report, July 2015, www.worldnuclearreport.org/-2015-.html
[10] The World Nuclear Association (66) and the IAEA (67) provide slightly higher numbers of reactors under construction. www.world-nuclear.org/info/Facts-and-Figures/World-Nuclear-Power-Reactors-and-Uranium-Requirements/

- In 2014 the share of nuclear power in the global electricity mix was less than 11%, for the third year in a row (10.8% in 2014). Nuclear power's share of global commercial primary energy production remained stable at 4.4% in 2014, the lowest level since 1984.
- Between 1977 and 2015, a total of 92 (one in eight) of all nuclear power construction sites were abandoned or suspended in 18 countries in various stages of advancement.
- Only two newcomer countries are actually building reactors − Belarus and the UAE.
- Countries accounting for 45% of the global population − China, Germany, Japan, Brazil, India, Mexico, the Netherlands, and Spain − generate more electricity from non-hydro renewables than from nuclear power (and of course the same point applies to the ~160 countries that do not have nuclear power reactors).



Nuclear Electricity Generation in the World.
Source: World Nuclear Industry Status Report, July 2015, www.worldnuclearreport.org/-2015-.html

https://www.iaea.org/PRIS/WorldStatistics/UnderConstructionReactorsByCountry.aspx

Table 1: Nuclear Reactors "Under Construction" (as of 1 July 2015)[53]

Country	Units	MWe (net)	Construction Start	Grid Connection	Delayed Startup (Units)
China	24	23,738	2009-2015	2015-2021	15
Russia	8	6,262	1983-2010	2015-2019	8
India	6	3,907	2002-2011	2015-2019	6
USA	5	6,320	1972-2013	2016-2020	5
South Korea	4	5,360	2008-2013	2016-2018	4
UAE	3	4,035	2012-2014	2017-2019	?
Belarus	2	2,218	2013-2014	2019-2020	?
Pakistan	2	630	2011	2016-2017	2
Slovakia	2	880	1985	2016-2017	2
Ukraine	1	1,900	1986-1987	2019	2
Argentina	1	25	2014	2018	?
Brazil	1	1,245	2010	2018	1
Finland	1	1,600	2005	2018	1
France	1	1,600	2007	2017	1
Total	62	59,033	1972-2015	2015-2021	47

Source: World Nuclear Industry Status Report, July 2015, www.worldnuclearreport.org/-2015-.html

Nuclear power growth forecasts

Growth projections should be considered in the context of the many historical examples of projections which have not been met. For example:

- In 1974, the IAEA forecast 4,450 GW globally in the year 2000[11] − the true figure was 352 GW (7.9% of the forecast).
- The IAEA forecast that there would be 14 new countries using nuclear power with a combined capacity of 52 GW by 1989[12] − the true figures were four countries (29% of the forecast) and 9 GW (17% of the forecast).
- In 1985, the IAEA's 'low' forecast was 502 GW in 2000 − the true figure was 350 GW (70% of the low forecast, 50% of the high forecast of 702 GW).[13]

Nuclear industry bodies continue to offer implausible growth forecasts. For example the World Nuclear Association in 2014 envisaged the start-up of 266 new reactors by 2030.[14] That would require completion of the 62 reactors now under construction, and start-to-finish construction of another 204 reactors − all in the space of 15 years.

The International Atomic Energy Agency has repeatedly revised its forecasts downwards since the Fukushima accident. The IAEA's 2014 projections are for total nuclear capacity growth of 8% to 88% by 2030 (401 GW to 699 GW).[15] The low projection (8%) is less than half the comparable projection (17%)

[11] http://fissilematerials.org/library/rr08.pdf
[12] http://trustandverify.wordpress.com/2010/10/01/428/
[13] www-pub.iaea.org/mtcd/publications/pdf/pub1304_web.pdf
[14] World Nuclear Association, 2014, 'The World Nuclear Supply Chain: Outlook 2030, http://online-shop.world-nuclear.org/bfont-size18pxthe-world-nuclear-supply-chain-broutlook-2030fontb-18-p.asp
[15] IAEA, July 2015, Nuclear Technology Review 2015, www.iaea.org/About/Policy/GC/GC59/GC59InfDocuments/English/gc59inf-2_en.pdf

from the IAEA just one year earlier.[16] To its credit, the IAEA has published information comparing its earlier projections with outcomes.[17] On the basis of that (and other) information, the high projections can be disregarded − historically, the IAEA's high projections have usually been grossly inaccurate. Even the IAEA's 'low' projections tend to be too high − but provide a reasonable guide nonetheless. Thus the IAEA's estimate of 8% nuclear capacity growth by 2030 − annual growth of less than 1% − can be considered a reasonable prediction.

Similar arguments apply to uranium demand. For example the OECD Nuclear Energy Agency and the IAEA estimated in a 2014 report that uranium demand would increase by 20−105% by 2035 compared to 2013.[18] The 20% figure is plausible, the 105% figure is not.

The 2015 edition of BP's annual *Energy Outlook* publication forecasts nuclear capacity growth of 1.8% p.a. between 2015 and 2035, compared to renewables growth of 6.3% p.a.[3]

Not even the most strident nuclear advocate would describe an annual growth rate of <1% to 1.8% as a nuclear power 'renaissance'. Thus, the 'renaissance' completely failed to materialise over the past decade and there is no prospect of a renaissance in the foreseeable future.

It is by no means certain that there will be any nuclear power growth at all.[19] That opinion is increasingly being voiced by nuclear industry 'insiders'. For example former World Nuclear Association executive Steve Kidd noted in a January 2015 paper that the "picture of the current reactors gradually shutting down with numbers of new reactors failing to replace them has more than an element of truth given the recent trends."[20]

Kidd elaborates:

"[W]e have seen no nuclear renaissance (instead, a notable number of reactor closures in some countries, combined with strong growth in China) ... Countries such as Germany and Switzerland that claim environmental credentials are moving strongly away from nuclear. Even with rapid nuclear growth in China, nuclear's share in world electricity is declining. The industry is doing little more than hoping that politicians and financiers eventually see sense and back huge nuclear building programmes. On current trends, this is looking more and more unlikely."[21]

Writing in *Oilprice.com*, Nick Cunningham argues that the nuclear industry is "failing miserably" to build new plants on time and within budget.[22] He writes:

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[16] IAEA, 24 Sept 2013, 'IAEA Issues Projections for Nuclear Power from 2020 to 2050', www.iaea.org/newscenter/news/2013/np2020.html
World Nuclear News, 25 Sept 2013, 'IAEA foresees continued growth in nuclear capacity', www.world-nuclear-news.org/NP-IAEA_foresees_continued_growth_in_nuclear_capacity-2509134.html
[17] Tables 33 and 34, p.56, www-pub.iaea.org/mtcd/publications/pdf/pub1304_web.pdf
[18] Joint report by the OECD Nuclear Energy Agency and the International Atomic Energy Agency, Uranium 2014: Resources, Production and Demand, Paris
[19] 'The nuclear renaissance is stone cold dead', 13 Jan 2014, www.businessspectator.com.au/article/2014/1/13/energy-markets/nuclear-renaissance-stone-cold-dead
[20] Steve Kidd, 21 Jan 2015, 'Is climate change the worst argument for nuclear?', www.neimagazine.com/opinion/opinionis-climate-change-the-worst-argument-for-nuclear-4493537/
[21] Steve Kidd, 21 Jan 2015, 'Is climate change the worst argument for nuclear?', www.neimagazine.com/opinion/opinionis-climate-change-the-worst-argument-for-nuclear-4493537/
[22] Nick Cunningham, 19 Feb 2015, 'Is There Any Hope Left For Nuclear Energy?', http://oilprice.com/Alternative-Energy/Nuclear-Power/Is-There-Any-Hope-Left-For-Nuclear-Energy.html

"Nuclear power plants have often suffered from cost overruns and delays, one factor (among many) that put the industry into a decades-long lull beginning in the early 1980's. The so-called "nuclear renaissance" was thought to put an end to these problems with a new generation of designs and modular construction. So far, it hasn't played out that way. Meanwhile, a tidal wave of nuclear reactors will close down over the next 20 years as their operating licenses expire. ... A massive build out of nuclear power in China is where the nuclear industry's best hopes reside, but it is unclear if even China can make up for the shrinking industry presence in the West ..."

Only in **China** can significant nuclear growth be projected. China has 22 operable reactors, 27 under construction and 64 planned. Significant, rapid growth can be expected unless China's nuclear program is derailed by a major accident or a serious act of sabotage or terrorism. That said, Chinese authorities have a history of failing to meet earlier projections − in 1985 authorities forecast 20 GW in 2000 but the true figure was 2.2 GW (11% of the forecast); and in 1996 authorities forecast 20 GW in 2010 but the true figure was 8.4 GW (42% of the forecast).[23]

There are serious concerns about China's nuclear program:

- Numerous insiders have warned about inadequate nuclear safety and regulatory standards in China.[24]
- In 2011, Chinese physicist He Zuoxiu warned that "we're seriously underprepared, especially on the safety front" for a rapid expansion of nuclear power. Qiang Wang and his colleagues from the Chinese Academy of Sciences noted in 2011 that China "still lacks a fully independent nuclear safety regulatory agency"[25], that China's nuclear administrative systems are fragmented among multiple agencies, and that China lags behind the US, France, and Japan when it comes to staff and budget to oversee operational reactors.[26]
- Corruption is another problem − for example in August 2009 the Chinese government dismissed and arrested China National Nuclear Corporation president Kang Rixin in a US$260 million corruption case involving allegations of bid-rigging in nuclear power plant construction.[27]
- A 2011 report by the State Council Research Office recommended that the National Nuclear Safety Administration "should be an entity directly under the State Council Bureau, making it an independent regulatory body with authority."[28]
- China's nuclear safety agency is still not independent. And there are other problems: salaries for regulatory staff are lower than in industry, and workforce numbers remain relatively low. The State Council Research Office report said that most countries employ 30−40 regulatory staff per reactor, but China's nuclear regulator had only 1000 staff.[29]

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[23] Mycle Schneider, Sept 2010, 'Nuclear Power in 2010: Radiant Future or Barrier to Change?', Presentation to the REFORM-Group Meeting, Salzburg, www.polsoz.fu-berlin.de/polwiss/forschung/systeme/ffu/veranstaltungen_aktuell/veranstaltungen_downloads/10_salzburg/schneider.pdf

[24] He Zuoxiu, 19 March 2013, 'Chinese nuclear disaster "highly probable" by 2030', www.chinadialogue.net/article/show/single/en/5808-Chinese-nuclear-di
South China Morning Post, 7 Oct 2013, 'China nuclear plant delay raises safety concern', www.scmp.com/business/china-business/article/1325973/china-nuclear-plant-delay-raises-safety-concern

[25] David Biello, 16 Aug 2011, 'China's nuclear ambition powers on', www.abc.net.au/environment/articles/2011/08/16/3293802.htm

[26] 22 June 2011, 'China needs improved administrative system for nuclear power safety', www.eurekalert.org/pub_releases/2011-06/acs-cni062211.php

[27] Keith Bradsher, 15 Dec 2009, 'Nuclear Power Expansion in China Stirs Concerns', www.nytimes.com/2009/12/16/business/global/16chinanuke.html?_r=2&

[28] World Nuclear Association, 9 December 2014, 'Nuclear Power in China', www.world-nuclear.org/info/Country-Profiles/Countries-A-F/China--Nuclear-Power/

[29] World Nuclear Association, 9 December 2014, 'Nuclear Power in China', www.world-nuclear.org/info/Country-Profiles/Countries-A-F/China--Nuclear-Power/

- China has grossly inadequate insurance and liability arrangements. Chinese authorities are slowly developing legislation which may improve the situation. Currently, liability caps are the lowest in the world.[30]
- China ranks poorly in the NTI Nuclear Materials Security Index − it is in the bottom fifth of the countries ranked. The NTI summarises: "China's nuclear materials security conditions could be improved by strengthening its laws and regulations for the physical security of materials in transport to reflect the latest IAEA nuclear security guidelines, and for mitigating the insider threat, particularly by requiring personnel to undergo more stringent and more frequent vetting and by requiring personnel to report suspicious behavior to an official authority. China's nuclear materials security conditions also remain adversely affected by its high quantities of weapons-usable nuclear materials, political instability, governance challenges, and very high levels of corruption among public officials."[31]

The Economist has summarised the problems and risks:[32]

[T]he headlong rush to nuclear power is more dangerous and less necessary than China's government admits. One of the main lessons of Fukushima was that politicised, opaque regulation is dangerous. China's rule-setting apparatus is also unaccountable and murky, and ambitious targets for a risky technology should ring warning bells.

Selling uranium to China in the current circumstances is arguably as irresponsible as the Australian uranium industry's history of supplying Japan while turning a blind eye to the grossly inadequate safety and regulatory standards there.

Recommendation 1: The Royal Commission should ask the federal government and uranium companies supplying China what they are doing about the serious problems with China's nuclear power industry (safety, security, corruption, inadequate regulation, etc.).

Patterns of stagnation or slow decline in **Western Europe** and **North America** can safely be predicted. Steve Kidd wrote in May 2014 that uranium demand (and nuclear power capacity) "will almost certainly fall in the key markets in Western Europe and North America" in the period to 2030.[33]

In January 2014, the European Commission forecast that **EU** nuclear generating capacity of 131 GWe in 2010 will decline to 97 GWe in 2025 before rising to 122 GWe in 2050 − still lower than the 2010 figure. The European Commission forecasts that nuclear's share of EU electricity generation will decline from 27% in 2010 to 21% in 2050, while the share held by renewables will increase from 21% to 51.6%, and fossil fuels' share will decline from 52% to 27%.[34]

The US has 99 operable reactors. Five reactors are under construction, "with little prospect for more" according to *Oilprice.com*.[35] Decisions to shut down just as many reactors have been taken in the past

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[30] 26 April 2014, 'What if China has a Fukushima?', www.globaltimes.cn/content/856971.shtml
See also WNN, 16 Sept 2014, 'Insurers can help improve the image of nuclear', www.world-nuclear-news.org/RS-Insurers-can-help-improve-the-image-of-nuclear-1609201401.html
[31] NTI Nuclear Materials Security Index, 2014, http://ntiindex.org/countries/china/
[32] 6 Dec 2014, 'China's rush to build nuclear power plants is dangerous', www.economist.com/news/leaders/21635487-chinas-rush-build-nuclear-power-plants-dangerous-make-haste-slowly
[33] Steve Kidd, 6 May 2014, 'The future of uranium – higher prices to come?', www.neimagazine.com/opinion/opinionthe-future-of-uranium-higher-prices-to-come-4259437
[34] World Nuclear News, 9 Jan 2014, 'Policies hold European nuclear steady', www.world-nuclear-news.org/EE-Politics-hold-European-nuclear-steady-0901144.html
[35] Nick Cunningham, 9 Feb 2014, 'Wind and Gas Forcing Out Nuclear in Midwest', http://oilprice.com/Latest-Energy-News/World-News/Wind-and-Gas-Forcing-Out-Nuclear-in-Midwest.html

few years, in addition to cancelled plans for new reactors and cancelled plans to increase the power of existing reactors.[36] The US Energy Information Administration estimated in April 2014 that 10.8 GW of US nuclear capacity − around 10% of the total − could be shut down by the end of the decade.[37]

The *Financial Times* noted in 2014 that the US nuclear industry has been particularly rattled by two recent decisions − the closures of Dominion Resources' Kewaunee plant in Wisconsin and Entergy's Vermont Yankee. Both were operating and licensed to keep operating into the 2030s, but became uneconomic to keep in operation.[38]

India has 21 operating reactors, six under construction and 22 planned. But India's nuclear program is in a "deep freeze" according to a November 2014 article in the *Hindustan Times*.[39] India's energy minister Piyush Goyal said in November 2014 that the government remains "cautious" about developing nuclear power. He pointed to waning interest in the US and Europe:

"This government would like to be cautious so that we are not saddled with something only under the garb of clean energy or alternate energy; something which the West has discarded and is sought to be brought to India."[40]

A November 2014 article in *The Hindu* newspaper noted that three factors have put a brake on India's reactor import plans: "the exorbitant price of French- and U.S.-origin reactors, the accident-liability issue, and grass-roots opposition to the planned multi-reactor complexes."[41] In addition, unresolved disagreements regarding safeguards and non-proliferation assurances are delaying US and European investment in India's nuclear program.[42]

Claims in early 2015 of a 'breakthrough' between the US and India on the liability impasse had little substance.[43] The Associated Press reported:

"India and America's declaration of a breakthrough in contentious nuclear energy cooperation has been met with a lukewarm response from industry and analysts. Few expect the potentially lucrative Indian market to suddenly become less complicated for U.S. nuclear companies."[44]

Other obstacles remain in addition to the liability issue, as energy and nuclear policy consultant Mycle Schneider notes:[45]

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[36] Peter Bradford, 12 July 2013, 'Nuclear renaissance was just a fairy tale', www.guardian.co.uk/environment/2013/jul/11/nuclear-renaissance-power-myth-us

[37] Reuters, 29 Apr 2014, 'U.S. expects about 10 pct of nuclear capacity to shut by 2020', http://in.reuters.com/article/2014/04/28/utilities-nuclear-eia-idINL2N0NK23D20140428

[38] Ed Crooks, 19 Feb 2014, 'Uneconomic US nuclear plants at risk of being shut down', www.ft.com/intl/cms/s/0/da2a6bc6-98fa-11e3-a32f-00144feab7de.html

[39] Shishir Gupta and Jayanth Jacob, 30 Nov 2014, 'Govt plans N-revival, focuses on investor concerns', www.hindustantimes.com/india-news/govt-plans-n-revival-looks-for-answers-to-investor-concerns/article1-1291627.aspx

[40] 6 Nov 2014, 'Govt cautious about tapping nuclear energy for power generation', www.thehindu.com/news/national/govt-cautious-on-westdiscarded-nuclear-technology-says-piyush-goyal-at/article6570575.ece

[41] Brahma Chellaney, 19 Nov 2014, 'False promise of nuclear power', www.thehindu.com/opinion/lead/false-promise-of-nuclear-power/article6612000.ece

[42] Indrani Bagchi, 19 Nov 2014, 'American officials put up hurdles, try to scuttle India-US nuclear deal', http://timesofindia.indiatimes.com/india/American-officials-put-up-hurdles-try-to-scuttle-India-US-nuclear-deal/articleshow/45198136.cms

[43] 'US−India 'breakthrough' met with scepticism', 5 March 2015, Nuclear Monitor, www.wiseinternational.org/nuclear-monitor/799/us%E2%88%92india-breakthrough-met-scepticism

[44] Associated Press, 27 Jan 2015, India nuke deals still thorny for US despite 'breakthrough' www.washingtonpost.com/business/india-nuke-deals-still-thorny-for-us-despite-breakthrough/2015/01/27/b0caba54-a620-11e4-a162-121d06ca77f1_story.html

"In reality, there is no real market for foreign nuclear companies in India, unless they bring their own funding. Under free market conditions it is not possible anymore to build a nuclear power plant anywhere in the world. So if new reactors are built in India or elsewhere, the projects are highly subsidized, either by the government − the taxpayer − or the ratepayer."

Views such as those expressed by Schneider can also be found in the industry literature. A February 2015 World Nuclear News article by Edward Kee from the Nuclear Economics Consulting Group noted that of the 69 reactors under construction around the world, only one is in a liberalized electricity market.[46]

Most nuclear growth is anticipated in economically and/or politically illiberal countries. The *Wall Street Journal* noted in February 2013 that "new nuclear works best in countries where consumers and financiers are shielded from its full costs − hardly the best basis for the industry's ever-elusive renaissance".[47]

Russia has 34 operating reactors, nine under construction and 31 planned. Only three reactors have commenced operation during the past decade. The pattern of slow or very slow growth is likely to continue. In any case the export of Australian uranium to Russia has been suspended in response to events in Ukraine/Crimea.

The Royal Commission could use the case of Russia to illustrate the vast gulf between reality and the rhetoric of the uranium industry and its supporters.[48] Claims were repeatedly made that uranium sales from Australia to Russia would generate $1 billion in annual export revenue. Even without the suspension of uranium exports to Russia, a plausible figure would be an order of magnitude lower than the $1b figure − and in reality scarcely any uranium was exported to Russia before the suspension was imposed by the Abbott government.

Richard Denniss from the Australia Institute has noted:

"Much has been written in recent years about the difficulty that the media seems to have sorting fact from fiction and distinguishing balance from barracking but the mining industry provides a clear example of the difficulties that all our media seem to have dealing with − an industry that spends more on public relations than some industries spend on research and development."[49]

South Korea has 23 operating reactors, five under construction and eight planned. Earlier plans for rapid nuclear expansion have been sharply reduced[50] in the aftermath of the Fukushima accident, a major scandal involving bribery and faked safety certificates for thousands of reactor parts[51], another scandal involving the cover-up of an accident that sent the temperature of a reactor core soaring, and a hacking

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[45] 28 Jan 2015, Breakthrough in US-India civil nuclear deal 'more symbolism than reality', www.dw.de/breakthrough-in-us-india-civil-nuclear-deal-more-symbolism-than-reality/a-18221115

[46] WNN, 4 Feb 2015, 'Can nuclear succeed in liberalized power markets?', www.world-nuclear-news.org/V-Can-nuclear-succeed-in-liberalized-power-markets-0420152.html

[47] Liam Denning, 6 Feb 2013, 'The Real Deterrent to Nuclear Power', www.wsj.com/articles/SB10001424127887324761004578285992381951734

[48] See the discussion and calculations in section 6 of: ACF, 2013, 'Yellowcake Fever: exposing the uranium industry's economic myths', www.acfonline.org.au/resources/yellowcake-fever-exposing-uranium-industrys-economic-myths

[49] www.canberratimes.com.au/opinion/mining-industrys-big-lie-20120217-1tepr.html

[50] Jane Chung / Reuters, 14 Jan 2014, 'South Korea cuts future reliance on nuclear power, but new plants likely', http://uk.reuters.com/article/2014/01/14/uk-nuclear-korea-idUKBREA0D05K20140114

[51] http://atomicpowerreview.blogspot.com.au/2013/10/south-korea-cables-fail-tests.html

attack on Korea Hydro's computer network.[52] One hundred people were arrested as a result of the safety scandals, including a former chief executive of Korea Hydro and Nuclear Power, a vice president of Korea Electric Power Corp., and a former deputy minister in charge of energy.[53]

Saudi Arabia last year announced plans to build 16 reactors by 2032. Already, that timeline has been pushed back from 2032 to 2040.[54] As with any country embarking on a nuclear power program for the first time, Saudi Arabia faces daunting logistical and workforce issues.[55] Numerous nuclear supplier are lining up to supply Saudi Arabia's nuclear power program but political obstacles could easily emerge, not least because Saudi officials (and royalty) have repeatedly said that the Saudi Kingdom will build nuclear weapons if Iran's nuclear program is not constrained.[56]

South Africa's 'on-again off-again' nuclear power program is on again with plans for 9.6 GW of nuclear capacity in addition to the two operating reactors at Koeberg.[57] In 2007, state energy utility Eskom approved a plan for 20 GW of new nuclear capacity. Areva's EPR and Westinghouse's AP1000 were short-listed and bids were submitted. But in 2008 Eskom announced that it would not proceed with either of the bids due to a lack of finance. Thus the latest plan for 9.6 GW of new capacity is being treated with scepticism.[58]

France's Lower House of Parliament voted in October 2014 to cut nuclear's share of electricity generation from 75% to 50% by 2025, to cap nuclear capacity at 63.2 GW, and to pursue a renewables target of 40% by 2030 with various new measures to promote the growth of renewables.[59] In March 2015, the opposition-controlled Upper House of Parliament passed a watered-down version of the Bill, with a committee of parliamentarians from both Houses tasked with trying to reach a compromise.[60] After months of debate, the French Parliament finally approved measures on 22 July 2015 that will reduce nuclear power's share of electricity generation to 50% by "around" 2025, and caps nuclear capacity at the current level of 63.2 GW.[61]

Meanwhile, giant French utility Areva, which is 85% state-owned, has amassed extraordinary debts and the French government is negotiating a rescue package and restructure. Areva posted losses in each of the past four years including a €4.83 billion (A$6.67b) loss in 2014. Areva's share value plunged to a

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[52] Heesu Lee, 15 Jan 2015, 'Fukushima Meltdowns Pervade S. Korea Debate on Reactor Life', www.bloomberg.com/news/2015-01-14/fukushima-meltdowns-pervade-korea-debate-on-longer-reactor-life.html

[53] World Nuclear News, 10 Oct 2013, 'Indictments for South Korea forgery scandal', www.world-nuclear-news.org/RS-Indictments_for_South_Korea_forgery_scandal-1010137.html

[54] Reuters, 19 Jan 2015, http://uk.reuters.com/article/2015/01/19/saudi-nuclear-energy-idUKL6N0UY2LS20150119?rpc=401

[55] Dan Yurman, 24 Jan 2015, 'Saudi Arabia delays its nuclear plans', http://neutronbytes.com/2015/01/24/saudi-arabia-delays-its-nuclear-plans/

[56] 'Saudi Arabia's nuclear power program and its weapons ambitions', Nuclear Monitor #791, 18 Sept 2014, www.wiseinternational.org/node/4195

[57] 'South Africa's stop-start nuclear power program', Nuclear Monitor #792, 2 Oct 2014, www.wiseinternational.org/node/4193

[58] Steve Thomas, July 2014, 'Nuclear technology options for South Africa', http://earthlife.org.za/www/wp-content/uploads/2014/09/nuclear-cost_report1.pdf

[59] 'France to cut nuclear's share of power market to 50% by 2025', 10 Oct 2014, www.platts.com/latest-news/electric-power/london/france-to-cut-nuclears-share-of-power-market-26900954
Michel Rose, 15 Oct 2014, 'French energy transition law to cut red tape on renewables', http://planetark.org/enviro-news/item/72327

[60] Michel Rose, 4 March 2015, 'Senate waters down French energy bill, committee to seek compromise', http://planetark.org/enviro-news/item/72881

[61] Tara Patel, 23 July 2015, 'France Passes New Energy Law Quadruples Carbon Price', www.bloomberg.com/news/articles/2015-07-23/france-passes-new-energy-law-quadruples-carbon-price
WNN, 23 July 2015, 'French energy transition bill adopted', www.world-nuclear-news.org/NP-French-energy-transition-bill-adopted-2307155.html

new historic low on 9 July 2015 − a value loss of 90% since 2007.[62] Areva chairman Philippe Varin said: "Areva's paradox is that it is a world leader in its sector and a company in crisis." Varin said the crisis was due to deficient management of big reactor projects and Areva's failure to adapt to a weaker global market following the 2011 Fukushima accident.[63]

Germany's government is systematically pursuing its policy of phasing out nuclear power by 2023. This phase out is on track, with the growth of renewables matching the decline in nuclear power generation[64], and the *Energiewende* enjoys wide political and community support.

Japan has 43 operable reactors − down from 55 before the Fukushima accident. All of the 43 reactors are shut down as of July 2015. Before the Fukushima accident, the Japanese government planned to add another 15−20 power reactors to the fleet of 55 giving a total of 70−75 reactors. There is considerable uncertainty as to how many reactors will be restarted. Even if three-quarters are restarted (which is at the upper end of informed estimates), Japan's nuclear power industry will be around half the size it might have been if not for the Fukushima accident. A Reuters analysis in 2014 concluded that fewer than one-third, and at most about two-thirds, of the reactors would pass NRA safety checks and clear the other seismological, economic, logistical and political hurdles needed to restart − the analysis was based on questionnaires and interviews with more than a dozen experts and input from the 10 nuclear operators.[65]

Japan provides one example of how data, used out of context, can create the impression of a renaissance when none exists. As of July 2015, the World Nuclear Association lists 43 reactors in the 'operable' category for Japan − without noting that none are operating. Three reactors are listed as under construction, nine reactors are listed as 'planned' and three are listed as 'proposed'.[66] From that decontextualised data, one would not know that the Japanese nuclear industry has been shaken to its foundations by the March 2011 Fukushima disaster.

The US provides another example of how data, used out of context, can create the impression of a renaissance when none exists. As of July 2015, the World Nuclear Association lists 99 reactors in the 'operable' category for the US, five under construction, five 'on order or planned', and 17 'proposed'.[67] Such figures are used to bolster the notion of a nuclear renaissance yet if there is any movement in US nuclear capacity in the next 10−20 years it will almost certainly be downwards.

Ageing reactors

The problem of ageing reactors came into focus in 2014 and will remain in focus for decades to come.[68]

Excluding Japan's 43 'operable' reactors (because none are operating and their future is uncertain; they are classified in the World Nuclear Industry Status Report as being in long-term outage)[69]:

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[62] www.worldnuclearreport.org/-2015-.html
[63] Geert De Clercq, 4 March 2015, 'Loss-making Areva bets on cost cuts, EDF cooperation, China', www.reuters.com/article/2015/03/04/areva-results-idUSL5N0W60I420150304
[64] http://reneweconomy.com.au/2015/the-myth-of-the-dark-side-of-germanys-energiewende-94542
[65] www.reuters.com/article/2014/04/01/japan-nuclear-restarts-idUSL1N0MM0AU20140401
[66] www.world-nuclear.org/info/Facts-and-Figures/World-Nuclear-Power-Reactors-and-Uranium-Requirements/
[67] www.world-nuclear.org/info/Facts-and-Figures/World-Nuclear-Power-Reactors-and-Uranium-Requirements/
[68] Nina Chestney and Geert De Clercq, 19 Jan 2015, 'Global nuclear decommissioning cost seen underestimated, may spiral', www.reuters.com/article/2015/01/19/nuclear-decommissioning-idUSL6N0UV2BI20150119
Greenpeace International, 2014, 'Lifetime extension of ageing nuclear power plants: Entering a new era of risk', www.greenpeace.nl/Global/nederland/2014/Documenten/Rapport%20Lifetime%20extension%20of%20ageing%20nuclear%20power%20plants.pdf
[69] World Nuclear Industry Status Report, July 2015, www.worldnuclearreport.org/-2015-.html

- the average age of the world's power reactors has been steadily rising and stands at 28.8 years as of mid-2015;
- over half of the total, or 199 reactors, have operated for more than 30 years, including 54 that have run for over 40 years.

Problems with ageing reactors include:
- the increased risk of accidents (and associated problems such as generally inadequate accident liability arrangements);
- debates over appropriate safety standards for reactors designed decades ago;
- an increased rate of unplanned reactors outages (at one point in 2014, less than half of the UK's nuclear capacity was available due to multiple outages[70]);
- costly refurbishments; and
- the costs associated with reactor decommissioning and long-term nuclear waste management.

One of the reasons it will be difficult for the nuclear power industry to grow over the next 25 years, and near-impossible for the industry to grow significantly, is that around half of the world's power reactors will be permanently shut down by 2040.

The International Energy Agency (IEA) said in its *World Energy Outlook 2014* report:[71]

A wave of retirements of ageing nuclear reactors is approaching: almost 200 of the 434 reactors operating at the end of 2013 are retired in the period to 2040, with the vast majority in the European Union, the United States, Russia and Japan.

IEA chief economist Fatih Birol said:[72]

Worldwide, we do not have much experience and I am afraid we are not well-prepared in terms of policies and funds which are devoted to decommissioning. A major concern for all of us is how we are going to deal with this massive surge in retirements in nuclear power plants.

The *World Energy Outlook 2014* report estimates the cost of decommissioning reactors to be more than US$100 billion up to 2040, adding that "considerable uncertainties remain about these costs, reflecting the relatively limited experience to date in dismantling and decontaminating reactors and restoring sites for other uses."

The IEA's head of power generation analysis, Marco Baroni, said that even excluding waste disposal costs, the final cost could be as much as twice as high as the $100 billion estimate, and that decommissioning costs per reactor can vary by a factor of four.[73]

Evidence of inadequate decommissioning funds is mounting. To give just one example, Entergy estimates a cost of US$1.24 billion to decommission the Vermont Yankee plant in the US, but the company's decommissioning trust fund for the plant − US$0.67 billion − is barely half that amount.[74]

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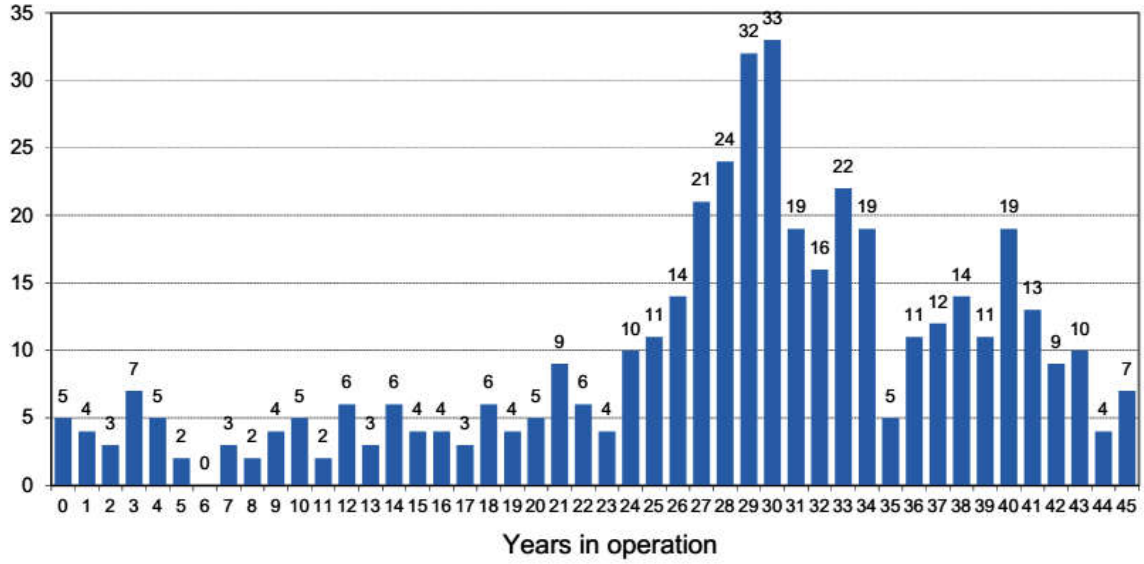
[70] Nuclear Free Local Authorities, 9 Dec 2014, 'NFLA concerns over the reliability of aging nuclear reactors in the UK', www.nuclearpolicy.info/docs/briefings/A241_%28NB127%29_Aging_nuclear_reactor_concerns.pdf
[71] International Energy Agency, 2014, 'World Economic Outlook 2014', www.worldenergyoutlook.org
[72] World Nuclear News, 12 Nov 2014, 'Nuclear industry shares IEA concern', www.world-nuclear-news.org/NP-Nuclear-industry-shares-IEA-concern-12111401.html
[73] Nina Chestney and Geert De Clercq, 19 Jan 2015, 'Global nuclear decommissioning cost seen underestimated, may spiral', www.reuters.com/article/2015/01/19/nuclear-decommissioning-idUSL6N0UV2BI20150119
[74] Robert Audette, 19 Dec 2014, 'Vermont Yankee decommissioning plan submitted to NRC', www.reformer.com/localnews/ci_27171602/vermont-yankee-decommissioning-plan-submitted-nrc



Power reactor age distribution.
Source: IAEA, July 2015, Nuclear Technology Review 2015, www.iaea.org/About/Policy/GC/GC59/GC59InfDocuments/English/gc59inf-2_en.pdf

The global uranium industry in the context of nuclear power stagnation

From the mid-2000s until the Fukushima disaster in 2011, expectations of a significant global expansion of nuclear power drove a sharp increase in uranium exploration, the start-up of numerous mines, and a uranium price bubble. However nuclear power has maintained its long-standing pattern of stagnation. Some uranium mines have shut down, some are operating at a loss. Uranium exploration has sharply declined. The uranium price is lower than the average cost of production − and well below the level that would entice mining companies to invest capital in new projects.[75]

Energy consultants Julian Steyn and Thomas Meade wrote in *Nuclear Engineering International* in October 2014:

"The uranium market is characterised by oversupply, which is forecast to continue through most of the current decade. The oversupply situation has been exacerbated by the greater-than-initially-expected decline in demand following Fukushima as well as the increase in primary supply during the same period. Existing production capacity and output from mines under development could cause total supply to exceed demand through the year 2020."[76]

Likewise, investment strategist Christopher Ecclestone from Hallgarten & Company wrote in November 2014:

[75] For general discussion on the uranium industry, see *Nuclear Monitor* #792, 2 Oct 2014, www.wiseinternational.org/node/4190
See also: 'Nuclear non-starter: Oversupplied, losing money and without a constituency', *Climate Spectator*, 16 Feb 2015, www.businessspectator.com.au/article/2015/2/16/energy-markets/nuclear-non-starter-oversupplied-losing-money-and-without
[76] Julian Steyn and Thomas Meade, 1 Oct 2014, 'Uranium market doldrums continue', www.neimagazine.com/features/featureuranium-market-doldrums-continue-4390747/

"There has indeed been a nuclear winter verging on an Ice Age over the last few years with bad news heaped upon bad news within the context of a pretty dismal financing situation for mining all around. ... The yellow mineral had made fools and liars of many in recent years, including ourselves."[77]

Likewise, RBC Capital Markets analysts said in June 2014 that worldwide supply currently exceeds demand, and that it does not expect the uranium industry's situation to improve until at least 2021 because of accumulated inventories.[78]

China, Japan and some other countries have amassed large stockpiles of uranium − industry analyst David Sadowski said in March 2014 that "many utilities are sitting on near-record piles" of uranium.[79]

China is the only country where significant nuclear growth can be anticipated in the coming 10−20 years. However, according to investment bank Macquarie, there are "serious question marks" about China's uranium requirements.[80] Macquarie believes that China has enough uranium stockpiled to meet demand for about seven years at forecast 2020 consumption rates − which is around three times greater than the current consumption rate.

Japan is estimated to have stockpiles of around 100 million pounds of uranium oxide.[81] To put that in perspective, world uranium requirements for power reactors amounted to around 171 million pounds in 2014. It will likely take a decade − perhaps longer − before Japan's stockpile is consumed given the protracted nature of the reactor restart process in the aftermath of the Fukushima disaster.[82] Even if all of Japan's 43 'operable' reactors were operating, it would take around five years to consume 100 million pounds of uranium oxide.

Steve Kidd, an independent consultant and economist who worked for the World Nuclear Association for 17 years, wrote in *Nuclear Engineering International Magazine* in May 2014 that "the case made by the uranium bulls is in reality full of holes" and he predicts "a long period of relatively low prices, in which uranium producers will find it hard to make a living".[83]

Kidd states that most nuclear power growth to 2030 will be concentrated in China and Russia. But "uranium demand will almost certainly fall in the key markets in Western Europe and North America", he states, and in Japan it will take a "long time to unwind the inventory accumulation". Only low-cost uranium mining operations will prosper while others "will struggle to stay in business and further mine closures ... are definitely on the horizon."[84]

Kidd argues that a new era has emerged, where the uranium market is split into three[85]:

- China will favour investing directly in mines to satisfy its requirements − China is not going to 'play ball' with the established uranium market.
- Russia will continue to be a significant nuclear fuel exporter but its own market will remain essentially closed to outsiders. Russia still has secondary supplies to tap into (plenty of surplus

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[77] http://investorintel.com/nuclear-energy-intel/nexgen-energy-nxe-v-survivor-nuclear-winter/
[78] Vicky Validakis, 6 June, 2014, 'Price collapse sees junior miner ditch uranium to focus on property development', www.miningaustralia.com.au/news/price-collapse-sees-junior-miner-ditch-uranium-to
[79] 29 March 2014, 'Conjuring Profits from Uranium's Resurgence: Interview with David Sadowski', http://theenergycollective.com/streetwiser/360291/conjuring-profits-uraniums-resurgence-david-sadowski
[80] Rhiannon Hoyle, 17 Jan 2015, 'Uranium Rally Running Low on Juice', http://online.barrons.com/articles/uranium-rally-running-low-on-juice-1421462807
[81] http://seekingalpha.com/article/2822326-charting-uraniums-gain-brent-cook-looks-for-sweet-spots-in-the-athabasca-basin
[82] www.businessspectator.com.au/article/2015/2/13/energy-markets/japan-plans-post-fukushima-nuclear-restart
[83] www.neimagazine.com/opinion/opinionthe-future-of-uranium-higher-prices-to-come-4259437/
[84] www.neimagazine.com/opinion/opinionthe-future-of-uranium-higher-prices-to-come-4259437/
[85] www.neimagazine.com/opinion/opinionthe-future-of-uranium-higher-prices-to-come-4259437/

highly-enriched uranium remains to be down-blended) and will follow the Chinese and invest directly in uranium assets if their own domestic production remains constrained.
- The established uranium producers will have the remainder of the market to satisfy and that will likely be declining in magnitude. In the US, the number of operating reactors will fall by 2030 and the overall European situation will be one of "gentle decline".

Kidd pulls the threads of his argument together[86]:

"This market segmentation and the way the Chinese and Russians will operate means that the two prime analytical devices utilised in the uranium market are both now useless. First, calculated annual world supply-demand balances (miraculously often showing a shortage after 3-5 years) are irrelevant in a segmented market, where key actors with expanding demand choose to go it alone. For a time in the early 2000s, it looked as if a globalised world nuclear fuel market could emerge, but this has not happened and it is arguably now going into reverse. Secondly, uranium supply curves (based on mine cost data), demonstrating the need for higher prices as demand expands, are also invalidated. China and Russia (and probably India too, if it eventually gets its nuclear act together) will develop uranium assets wherever it best suits them. They have the confidence to bypass the conventional market, which could increasingly become merely a sideshow."

Kidd concludes[87]:

"In this fifth age of uranium, prices will essentially be determined by the cash costs of production of operating mines (and not by the full costs of future mines). This means a reversion to the long period of low (but relatively stable) uranium prices of the late 1980s and 1990s (the third age), but at a higher level to reflect the greater level of production now, the escalation of mining costs and the movements in currency exchange rates. The shortages predicted by many analysts (leading to rapid price increases to provide good rates of return on their favourite projects) are purely a mirage. ***The outlook is therefore not favourable for either current or prospective uranium producers. Only those with low-cost operations will prosper. Others will struggle to stay in business and further mine closures ... are definitely on the horizon."*** *(emphasis added)*

With stagnant demand and large stockpiles, uranium miners have been left clutching at straws. Some hoped that supply from Russia might be curbed in response to Western sanctions, thus breathing some life into the uranium industry elsewhere − but that has not eventuated.

Some hoped that dwindling secondary supply sources − in particular, the end of the US−Russia Megatons to Megawatts uranium downblending program − would breathe life into the uranium industry. But the end of the Megatons to Megawatts program has had little or no impact. Raymond James analyst David Sadowski noted in August 2014:[88]

"[T]he end of the Megatons to Megawatts high-enriched uranium (HEU) deal was long anticipated to usher in a new period of higher uranium prices. But the same plants that were used to down-blend those warheads can now be used for underfeeding and tails re-enrichment. In this way, the Russian HEU-derived source of supply that provided about 24 million pounds (24 Mlb) to the market did not disappear completely; the supply level was just cut roughly in half."

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[86] www.neimagazine.com/opinion/opinionthe-future-of-uranium-higher-prices-to-come-4259437/
[87] www.neimagazine.com/opinion/opinionthe-future-of-uranium-higher-prices-to-come-4259437/
[88] Peter Byrne, 5 Aug 2014, 'Why predictions of uranium price boom flopped', www.mineweb.com/mineweb/content/en/mineweb-uranium?oid=249357&sn=Detail

And if there was a shortfall, surplus weapons material is just one of the secondary sources that can reduce demand for primary mine production. Other secondary sources are underfeeding at enrichment plants (getting more uranium-235 from a given volume of uranium ore), re-enrichment of tails material, government and commercial inventories, and uranium recycled from reprocessing plants.

Steve Kidd argues that the replacement of inefficient gaseous diffusion enrichment plants with centrifuge enrichment plants is a "crucial" factor:[89]

"Another crucial factor has been a fundamental realignment in the relationship between uranium and enrichment requirements. The closure of the inefficient gaseous diffusion enrichment plants removed the high marginal cost production which had propped up prices, while notably higher uranium prices in themselves encouraged the use of higher enrichment (through reducing the optimum "tails assay"). Enrichment is now expected to remain cheap and abundant as centrifuge plants are modular and capacity can be expanded relatively easily to meet demand, so this substitution of enrichment for uranium will continue to be important."

Huge stockpiles of depleted uranium represent "an attractive resource while there is overcapacity in enrichment and cheaper prices", Kidd states.[90]

Indeed some of the same enrichment plants that were used for the Megatons to Megawatts program are now being used for underfeeding and tails re-enrichment as David Sadowski noted in August 2014:[91]

"[T]he end of the Megatons to Megawatts high-enriched uranium (HEU) deal was long anticipated to usher in a new period of higher uranium prices. But the same plants that were used to down-blend those warheads can now be used for underfeeding and tails re-enrichment. In this way, the Russian HEU-derived source of supply that provided about 24 million pounds to the market did not disappear completely; the supply level was just cut roughly in half."

Australia's uranium industry

Politicians, academics and uranium industry representatives have drawn comparisons between the potential of Australia's uranium industry and Saudi oil revenue. The comparisons do not stand up to scrutiny. Using 2011 data, Saudi oil exports were 466 times greater than revenue from Australian uranium exports; Australia would need to supply entire global uranium demand 31 times over to match Saudi oil revenue; and if all of Australia's Reasonably Assured plus Inferred uranium resources (to US$130/kg U) were mined and sold at the price realised for 2011/12 uranium exports, the one-off economic windfall would fall short of annual Saudi oil revenue by $128 billion.[92]

From 2011 to 2013, uranium was produced in 21 countries, with Kazakhstan, Canada and Australia as the largest producers, accounting for approximately 63% of world production. Australia now accounts for approximately 11% of global production, compared to Australia's 2002−2011 average of 18.2%.[93]

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[89] www.neimagazine.com/opinion/opinionthe-future-of-uranium-higher-prices-to-come-4259437/
[90] www.neimagazine.com/opinion/opinionthe-future-of-uranium-higher-prices-to-come-4259437/
[91] www.mineweb.com/mineweb/content/en/mineweb-uranium?oid=249357&sn=Detail
[92] See the discussion and calculations in section 5 of: ACF, 2013, 'Yellowcake Fever: exposing the uranium industry's economic myths', www.acfonline.org.au/resources/yellowcake-fever-exposing-uranium-industrys-economic-myths
[93] ACF, 2013, 'Yellowcake Fever: exposing the uranium industry's economic myths', www.acfonline.org.au/resources/yellowcake-fever-exposing-uranium-industrys-economic-myths

Australia's uranium production of 5,000 tonnes in 2014 was the lowest for 16 years.[94] The industry generates less than 0.2 per cent of national export revenue (0.19% in 2013/14[95]) and accounts for less than 0.02 per cent of jobs in Australia.[96]

Claims that Australia should aspire to a market share commensurate with our percentage of the world's known uranium reserves generally overlook the point that Olympic Dam accounts for a large majority (>70%) of Australia's uranium reserves.

According to a 2012 report[97] by the federal Bureau of Resources and Energy Economics, Australia's identified uranium resources have more than doubled in the past two decades and increased by 62% from 2006 to 2010. However a large majority of the increase comes from revised estimates of Olympic Dam (first discovered in 1975). New resource discoveries include Beverley Four Mile (SA − 2005), Samphire (SA − 2007), Lake Mackay (WA − 2011), and some other mostly small, technically challenging deposits − primarily in WA and Queensland (the ban on uranium mining has been reinstated in Queensland).

Another point that is overlooked by the uranium industry is that a vast expansion of uranium mining in Australia would inevitably result in reduced global prices. The plan to mine and export 19,000 t U3O8 annually from Olympic Dam, as envisaged under the abandoned mega-expansion, would have resulted in Olympic Dam producing about one-quarter of global uranium requirements (with an estimated global requirement in 2015 of 66,883 tU or 78,855 tU3O8[98]). As Flinders University academic Richard Leaver said of an earlier period: "In essence, the idea that world prices could remain high while Australian production skyrocketed required that the basic laws of supply and demand be suspended."[99]

Richard Leaver further notes[100]:

'Potential' is one of the most powerful chemicals available to the political alchemist. Any individual, firm or sector deemed to have potential is relieved of a massive and perpetual burden − the need to account for past and present achievements (or, more probably, the lack of them). ... The history of Australian involvement in the civil uranium industry offers an excellent example of this alchemy at work.

Industry and government have a long track record of providing implausible uranium industry growth estimates.

The Australian Uranium Association frequently and prominently promoted a consultant's estimate of 14,000 t U3O8 exports in 2014, earning $1.7 billion. But production in 2014 was less than half that figure (5001 tU[101] or 5896 t U3O8).

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[94] World Nuclear Association, 23 Jan 2015, Weekly Digest, http://us1.campaign-archive1.com/?u=140c559a3b34d23ff7c6b48b9&id=e08ac096b6&e=ae5ca458a0

[95] Uranium exports in FY 2013/14: $622m
www.world-nuclear.org/info/Country-Profiles/Countries-A-F/Australia/
Total national export revenue (goods and services) in FY 2013/14: $332 billion
www.trademinister.gov.au/releases/Pages/2014/ar_mr_140805.aspx?ministerid=3

[96] See section 2 (export revenue) and section 3 (employment) in: ACF, 2013, 'Yellowcake Fever: exposing the uranium industry's economic myths', www.acfonline.org.au/resources/yellowcake-fever-exposing-uranium-industrys-economic-myths

[97] www.bree.gov.au/documents/publications/energy-in-aust/energy-in-australia-2012.pdf

[98] www.world-nuclear.org/info/Facts-and-Figures/World-Nuclear-Power-Reactors-and-Uranium-Requirements/

[99] http://books.google.com.au/books?id=QdOkh26w3McC&pg=PA92

[100] http://books.google.com.au/books?id=QdOkh26w3McC&pg=PA88

[101] www.world-nuclear.org/info/Facts-and-Figures/Uranium-production-figures/

The consultant's report was produced before the Fukushima disaster, but even post-Fukushima projections have proven to be inaccurate:

- In a 2012 paper[102], the Australian Uranium Association predicted production of 9,800 t U3O8 in 2014, but actual production in 2014 was 5,896 t U3O8 or just 60% of the estimate.
- In June 2011 (three months after the Fukushima disaster), the Australian Uranium Association claimed there were "good prospects that four or five projects in WA will begin operation in the next three to four years". No mines are operating in WA as of July 2015.

The federal Bureau of Resources and Energy Economics (BREE) also has a track record of providing inaccurate and inflated estimates, even in the aftermath of the Fukushima disaster. For example a March 2012 BREE report[103]:

- estimated that the spot price would average around US$53/lb in 2012, but it fell to US$43.50 (and the average was around US$48).
- estimated export revenue of $708 million in 2011/12, but the true figure was $607 million.
- estimated 15 reactor restarts in Japan in 2012, but there were only two restarts (and no reactors are currently operating as of July 2015).
- estimated revenue of $1.69 billion in 2016/17 − an estimate that stretches credulity in light of figures in recent years ($610m in 2010/11; $607m in 2011/12; $823m in 2012/13; and $622m in 2013/14[104]).

Along with inflated, inaccurate estimates of nuclear power growth and demand for Australian uranium, predictions regarding the uranium price have also repeatedly proven to be inaccurate and inflated.[105]

Export policy / customer countries

The industry hopes that bilateral nuclear cooperation agreements concluded over the past decade with China, Russia and the UAE − along with the nuclear cooperation agreement with India, currently being scrutinised by federal Parliament's Joint Standing Committee on Treaties − will lead to export growth. Increased sales to China can be anticipated (although the points made earlier by Steve Kidd need to be kept in mind). Sales to Russia have been suspended − and in any case should they ever be resumed it is likely to be a small market given the slow pace of nuclear power growth in Russia and the country's domestic uranium resources. It is unclear whether significant growth will be achieved in India and current uranium demand is very low. The UAE is building its first reactors so will be at most a small market.

There is little prospect for growth in other current export markets for Australian uranium:

- Plans to expand nuclear power (or at least to maintain current capacity with new build) are in trouble in the UK, the USA and Canada.
- Germany and Belgium plan to abandon nuclear power.
- The restart of reactors in Japan promises to be a protracted, contentious affair and Japan has a very large uranium inventory.

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[102] http://web.archive.org/web/20130425205831/http://www.aua.org.au/Content/AUASubDEWP.aspx

[103] http://web.archive.org/web/20130427033414/http://www.bree.gov.au/documents/publications/req/REQ-Mar-2012.pdf
See also the discussion in ACF, 2013, 'Yellowcake Fever: exposing the uranium industry's economic myths', www.acfonline.org.au/resources/yellowcake-fever-exposing-uranium-industrys-economic-myths

[104] www.world-nuclear.org/info/Country-Profiles/Countries-A-F/Australia/

[105] See section 5 in ACF, 2013, 'Yellowcake Fever: exposing the uranium industry's economic myths', www.acfonline.org.au/resources/yellowcake-fever-exposing-uranium-industrys-economic-myths

- South Korea's nuclear industry has been hit by a series of scandals including bribery, corruption and cover-ups, and the proportion of South Koreans who consider nuclear power safe fell from 71% in 2010 to 35% in 2012.[106]
- France plans to reduce its reliance on nuclear power.
- Taiwan, Finland, and Spain have fewer than 10 reactors each and will remain, at most, small markets.
- Sweden has 10 reactors, with no scope for growth under existing government policy.

Particular mines

The Ranger open-cut mine in the NT has been mined out and the planned Ranger 3 Deeps underground mine seems very unlikely to go ahead.[107] The uranium industry in the NT may come to an end when the last of the Ranger ore stockpile is milled in around two years time.[108]

Energy Resources of Australia (ERA) attempted to develop the Jabiluka mine under the Howard government despite the unanimous opposition of Mirarr Traditional Owners, but that project was halted and is unlikely to be revived.

ERA has posted losses for each of the past five years, totalling over $500 million. ERA has struggled with the political and economic impacts of a December 2013 leach tank collapse at Ranger resulting in the spillage of 1.4 million tonnes of radioactive slurry[109]; the collapse of a ventilation shaft in 2014[110]; and the revelations of a whistleblower published in the *Mining Australia* magazine (and elsewhere) in May 2014.[111]

In South Australia, BHP Billiton:
- cancelled the planned open-pit mega-expansion of the Olympic Dam copper-uranium mine in 2012 (although more modest expansion plans are being studied);
- has retrenched hundreds of workers at Olympic Dam in recent years[112];
- disbanded its Uranium Division in 2012; and
- sold the Yeelirrie uranium lease in WA in 2012 for around 11% of the nominal value of the uranium resource.

Just months after first production at the Honeymoon uranium mine in 2011, project partner Mitsui announced its decision to withdraw as it "could not foresee sufficient economic return from the project". In 2013, the mine owner − a subsidiary of Russia's Rosatom − put the mine into extended care-and-maintenance because it was running at a loss.[113]

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[106] www.reuters.com/article/2013/01/08/us-nuclear-korea-idUSBRE90704D20130108
[107] Nadia Daly, 22 June 2015, 'Energy Resources of Australia board members resign after stalled expansion of Kakadu's Ranger uranium mine', www.abc.net.au/news/2015-06-22/era-board-members-resign-kakadu-ranger-mine-stalled-expansion/6564052
[108] Matthew Stevens, 2 April 2015, 'Rio Tinto worried about ERA's Ranger uranium mine', www.afr.com/business/mining/uranium/rio-tinto-worried-about-eras-ranger-uranium-mine-20150402-1mctl1
[109] Gundjeihmi Aboriginal Corporation, 17 April 2014, 'Held To Ransom: Rio Tinto's radioactive legacy at Kakadu', www.mirarr.net/media_releases/held-to-ransom-rio-tinto-s-radioactive-legacy-at-kakadu
[110] Ben Hagemann, 12 May 2014, 'Shaft collapse brings new setbacks to Ranger 3 Deeps uranium operation', www.miningaustralia.com.au/news/shaft-collapse-brings-new-setbacks-to-ranger-3-dee
[111] Ben Hagemann, 5 May 2014, 'Running amok at Ranger Uranium Mine', www.miningaustralia.com.au/features/running-amok-at-ranger
[112] Simon Evans, 30 Jan 2015, 'Up to 300 jobs to go at BHP's Olympic Dam mine', www.smh.com.au/business/mining-and-resources/up-to-300-jobs-to-go-at-bhps-olympic-dam-mine-20150130-1327kb.html
[113] Reuters, 13 Nov 2013, 'Russia's Rosatom to mothball uranium mine expansion projects', www.reuters.com/article/2013/11/13/russia-rosatom-idUSL5N0IY1E720131113

Beverley Four Mile started production in 2014, at the same time as the nearby Beverley mine was put into care-and-maintenance. *The Advertiser* reported: "South Australia's newest mine will lose money and won't create any jobs."[114] Alliance Resources plans to sell its 25% stake in Beverley Four Mile.[115]

Uranium exploration in the Arkaroola Wilderness Sanctuary − a serious failure of SA government oversight/regulation

In November 2013, Marathon Resources gave up on the uranium sector, stating that the "risks were more likely to exceed rewards".[116] Marathon was arguably one of the 'corporate cowboys' of the uranium sector, having been found guilty of illegally disposing of radioactive materials in the Arkaroola Wilderness Sanctuary.[117]

Illegally dumped material included 22,800 calico bags containing drill cuttings, 16 steel and four plastic drums, 1500 empty plastic bags, folding seats, tyres, safety suits, aluminium trays, PVC pipes, oil and air filters, bottles and cans and polystyrene foam.

In addition, the Arkaroola Wilderness Sanctuary managers noted other problems with Marathon's activities at Mt Gee[118]:

- numerous hydrocarbon spills;
- Marathon's contractors allegedly stole 90,000 litres of rainwater;
- Marathon employee/s allegedly stole fluorite from the Mt Gee Geological Monument[119]; and
- the failure to follow safety procedures resulting in loss of wildlife.

It is important for the Royal Commission to note that Marathon's illegal activities were uncovered by detective work by the managers of the Arkaroola Wilderness Sanctuary. Those activities were not detected by government regulators. If not for the detective work of the managers of the Arkaroola Wilderness Sanctuary, the activities would likely be continuing to this day. The saga represents a serious failure of the SA government's oversight of the uranium mining industry.

Recommendation 2: The Royal Commission should ask the SA government what steps have been taken to prevent a recurrence of problems such as those that arose with Marathon Resources and what regulatory and monitoring changes have been adopted in response to this situation.

Corporate governance at Beverley

Fortune Magazine details one of the controversies surrounding General Atomics' subsidiary Heathgate Resources' Beverley uranium mine in SA.[120] When uranium prices increased in the mid-2000s, the

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[114] Chris Russell, 26 June 2014, 'Mining company Quasar opens Four Mile uranium mine near Arkaloola', www.adelaidenow.com.au/business/mining-company-quasar-opens-four-mile-uranium-mine-near-arkaloola/story-fni6uma6-1226966919583?nk=33cc12265a6414070d671f9c7d758200

[115] 14 July 2015, 'Alliance Res" Quasar to pay $74m to take Four Mile project', www.miningbusiness.net/content/alliance-res-quasar-pay-74m-take-four-mile-project

[116] AAP, 21 Nov 2013, 'Explorer says uranium project unviable', www.heraldsun.com.au/business/breaking-news/explorer-says-uranium-project-unviable/story-fni0xqe4-1226765298924

[117] http://australianmap.net/mt-gee/

[118] http://australianmap.net/mt-gee/

[119] http://unknownsa.blogspot.com.au/2008/09/case-of-missing-minerals.html

[120] Barney Gimbel, 31 Oct 2008, 'The predator', Fortune Magazine,
www.foe.org.au/anti-nuclear/issues/oz/u/isl/blue
http://money.cnn.com/2008/10/28/magazines/fortune/predator_gimbel.fortune/index.htm
http://archive.fortune.com/2008/10/28/magazines/fortune/predator_gimbel.fortune/index.htm

company was locked into long-term contracts to sell yellowcake from Beverley at earlier, lower prices. Heathgate devised plans to renegotiate its legally-binding contracts. Customers were told that production costs at Beverley were higher than expected, that production was lower than expected, and that a failure to renegotiate contracts would force Heathgate to file for bankruptcy. However former employees said that General Atomics (GA) CEO Neal Blue had allegedly directed Heathgate to increase its production costs. Customers were not told that bankruptcy was unlikely since GA had agreed to continue providing Heathgate with financial assistance. Two of Heathgate's Australian directors consulted an attorney who advised them that the plan could be considered a conspiracy to defraud. They left the company. Exelon, one of Heathgate's uranium customers, sued. The lawsuit was settled for about $41 million. Because of the increased uranium price, Blue ended up well in front despite the cost of the settlement with Exelon − more than $200 million in front by some estimates. Blue was unrepentant: "It made more sense to, in essence, just pay the fine."

Here is an excerpt from the Fortune Magazine article:

> *In 2001, when Blue [Neal Blue, CEO of General Atomics] started producing the radioactive metal, it sold for approximately $8 a pound on the spot market. Three years later the price had about doubled, but Blue was locked into long-term contracts to sell much of the metal to utilities at close to 2001 prices.*
> *Realizing the company was losing a tremendous opportunity, his subordinates allegedly devised a plan. An internal memo prepared by General Atomics' uranium subsidiary, Heathgate, in March 2004, recommended canceling or restructuring the contracts. The memo presented four options for backing out of the various deals, ranging from an intentional failure to deliver to allowing the subsidiary to file for bankruptcy.*
> *Blue's company chose a controversial middle ground. It would approach customers and ask for concessions, saying its cost of production was higher than expected and that the mine was producing less than it had anticipated. Some customers were handed documents confirming those assertions and suggesting that if the contracts weren't renegotiated, Heathgate would have to file for bankruptcy.*
> *What the companies weren't told was that, according to former employees, Blue had allegedly directed the company to increase its costs. Plus the company couldn't immediately go broke, since GA had agreed to continue providing Heathgate financial assistance − another fact conveniently left out of reports to customers.*
> *Many of Blue's longtime employees saw this as tantamount to railroading customers. Two of Heathgate's Australian directors, Mark Chalmers and David Brunt, were so worried about the legality of what they were doing that they consulted an outside attorney. That lawyer advised them that implementing the plan could be considered a "conspiracy to defraud and the commission of at least one criminal offense by each director, which would be very difficult to defend." Soon Chalmers and Brunt were no longer employed by Heathgate.*
> *Most customers agreed to renegotiate. But as the price of uranium continued to skyrocket − it had reached over $40 by early 2006 − Heathgate again told its customers that it was experiencing higher than expected production costs, lower than anticipated volumes, and did not have enough uranium to fulfill its orders.*
> *The lawsuits allege that these contentions were grossly exaggerated. That year, Blue's executives told Chicago-based Exelon, a $19-billion-a-year utility, that Heathgate would not deliver any uranium unless Exelon released them from the rest of the contracts. When the company refused, Heathgate and GA informed it that they would make no more deliveries. Exelon sued.*

See also: Nick O'Malley and Ben Cubby, 30 July 2009, 'Arms maker behind uranium mine settled fraudulent pricing case', Sydney Morning Herald, www.smh.com.au/national/arms-maker-behind-uranium-mine-settled-fraudulent-pricing-case-20090729-e1lx.html

But Blue figured that didn't matter. He says the most they could sue him for was the "maximum liquidated price," or the amount of uranium times the price in the contract. In the meantime he could sell that disputed metal on the spot market for prices that peaked last year at nearly $140 a pound.
Exelon's lawsuit against General Atomics' parent company was settled in the spring for about $41 million, according to Exelon's SEC filings. The amount Blue made selling that same uranium on the spot market? More than $200 million, by some estimates.
While Blue won't discuss the specifics of the case − the settlement agreement is confidential − he doesn't seem concerned by the allegations in the lawsuits. In fact, he is utterly unrepentant.
"If you're a profit-center manager, you look at what are your contractual obligations," Blue says. "It's not your obligation to give as much as possible from your company to someone else.... It made more sense to, in essence, just pay the fine."

Federal Ministers were 'unavailable for comment' in response to Fairfax Media requests.[121]

Recommendation 3: The Royal Commission should determine what action if any the federal and SA governments took in response to allegations of corporate impropriety by General Atomics / Heathgate as detailed in Fortune Magazine.

General Atomics / Heathgate has employed at least one private investigator to infiltrate environment groups in Australia.[122] The infiltrator, known as 'Mehmet', had previously infiltrated NGOs as part of an undercover police operation before he moved into the private sector to set up his own security company, Universal Axiom. When asked about the company's tactics, a Heathgate spokesperson said the company was privately owned and had a policy of not responding to media questions. 'Mehmet' had previously been hired by North Ltd, operator of the Ranger uranium mine, before its takeover by Rio Tinto in 2000. Former North Ltd executives confirmed the company's use of two other intelligence firms.

The inflated and inaccurate 'intelligence' provided by 'Mehmet' was partly responsible for a grossly disproportionate police response to a small protest at the Beverley uranium mine. Excessive police actions against environmentalists, local Aboriginal people and the media included the capsicum spraying of an 11-year old Adnyamathanha girl.[123] After a 10-year legal case, 10 people were awarded a total of $700,000 damages.[124] Heathgate Resources supported the excessive police actions (in a media release which is no longer available online).

Recommendation 4: The Royal Commission should recommend the enactment of legislation outlawing the infiltration of NGOs by mining companies.

Recommendation 5: The Royal Commission should recommend the enactment of legislation outlawing police infiltration of NGOs involved in peaceful protest activities.

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[121] Nick O'Malley and Ben Cubby, 30 July 2009, 'Arms maker behind uranium mine settled fraudulent pricing case', Sydney Morning Herald, www.smh.com.au/national/arms-maker-behind-uranium-mine-settled-fraudulent-pricing-case-20090729-e1lx.html
[122] Richard Baker and Nick McKenzie, 17 Oct 2008, The Age, 'Former officer hired to spy', www.theage.com.au/national/former-officer-hired-to-spy-20081016-52e3.html
[123] Peter Burdon, ABC, 10 July 2012, 'Peaceful dissent and a lizard's revenge', www.abc.net.au/environment/articles/2012/07/10/3541989.htm
9 April 2010, 'Anti-nuke protesters awarded $700,000 for 'feral' treatment', www.smh.com.au/national/antinuke-protesters-awarded-700000-for-feral-treatment-20100409-rxyv.html
[124] Court decision: www.austlii.edu.au/au/cases/sa/SASC/2010/95.html

The 2005−07 uranium bubble

The uranium bubble that peaked in 2007 was a sadly familiar case of speculative mining of the market. Journalist Marcus Priest provided a detailed account in the *Australian Financial Review* in May 2007.[125] Priest described some of the practices:

- shallow drilling or drilling beside an old hole that had good grades (called 'address pegging' or 'nearology').
- claiming to have found a geological type resembling a known deposit (e.g. Olympic Dam-style mineralisation).
- citing in-situ values for possible deposits without any reference to the cost, viability or legality of mining.
- using a lower cut-off grade of recoverable uranium to inflate the size of the estimate.
- capital raising or floating based on nothing more than applications for exploration leases which may never be granted because for various reasons such as environmental constraints (e.g. Fission Energy had licence applications in a WA national park and nature reserve).
- conflating a tenement application with a "project".
- companies with little or no experience, and a track record of jumping from one fad to the next, jumping on the uranium bandwagon.
- conflating the old and the new − Priest cites the example of Reefton Mining announcing a "major new uranium discovery" in Namibia which was in fact discovered in the 1970s.
- Spending only a small fraction of funds raised on exploration.

Michael West wrote in *The Age* in 2011[126]:

Until now inveterate fraudsters, even convicted heroin traffickers, have happily promoted their floats on the ASX. Of the 2300-odd companies listed on the bourse it would be safe to say a couple of hundred are simply pump-and-dump schemes, executive options scams and the like that are controlled by people whose primary intent is to mine wallets, not mineral deposits.

Until now, the same promoters have beaten a path back to the market − decade in, decade out − pouncing on every fad, boom and bubble. That they haven't been required to disclose their myriad failures − before "backdoor listing" the likes of a "uranium" asset into a nickel explorer's shell, itself born from a dotcom play, having emerged from the ruins of a biotechnology float − has played nicely into the hands of the promoters, brokers, lawyers, accountants and other capital markets fee-takers. Retail investors, though, have been savaged time and again.

Mechanisms have been developed seeking to address the overinflation of resource estimates.[127] Changes to the requirements of the Joint Ore Reserves Committee code were expected to come into effect in December 2013 − for example a pre-feasibility level study will have to be conducted before including an estimate of an ore reserve in a public report. However deficiencies remain and there seems to be little or no appetite or activity to address a raft of other problems.

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[125] Marcus Priest, 26 May 2007, 'Uranium Bubble?', www.foe.org.au/sites/default/files/Uranium%20Bubble%20AFR%202007.pdf

[126] Michael West, 16 April 2011, 'Not just another crackdown', www.theage.com.au/business/not-just-another-crackdown-20110415-1dhpk.html

[127] www.jorc.org/about.asp

Moreover, compliance and regulation remain compromised − the JORC Committee has no powers[128], the ASX prefers the light touch of providing "additional guidance" to companies, and ASIC rarely prosecutes.[129]

Meanwhile, uranium mining companies are resisting reform. Examples include Rio Tinto and BHP Billiton lobbying the European Union to abandon plans to enforce full financial disclosure on all projects including those in developing nations[130], and Paladin Energy lobbying against proposed changes to Australia's anti-bribery and corruption laws in relation to mining in Africa.[131]

A detailed timeline of the 2005−07 speculative uranium bubble in Australia and its aftermath is posted online.[132]

1.8 Would an expansion in extraction activities give rise to new or different risks for the health and safety of workers and the community? If so, what are those risks and what needs to be done to ensure they do not exceed safe levels?

Radiation and health

The difference between uranium mining and the mining of most other minerals is radiation exposure. (There are also radiological risks involved with some other mining operations, e.g. rare earths, mineral sands.)

Question 1.8 implies that there is a safe level of exposure to ionising radiation. Yet the consensus or near-consensus scientific position is that there is no safe level.

The Royal Commission will likely receive submissions claiming that the 'modern' scientific view is that low-level radiation exposure is harmless (or even beneficial) − but the consensus or near-consensus scientific position is that there is no safe level.

For example, the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) states in a 2010 report that "the current balance of available evidence tends to favour a non-threshold response for the mutational component of radiation-associated cancer induction at low doses and low dose rates."[133]

Likewise, the 2006 report of the US National Academy of Sciences' Committee on the Biological Effects of Ionising Radiation (BEIR) states that "the risk of cancer proceeds in a linear fashion at lower doses without a threshold and … the smallest dose has the potential to cause a small increase in risk to humans."[134]

Likewise, a report in the *Proceedings of the National Academy of Sciences* states: "Given that it is supported by experimentally grounded, quantifiable, biophysical arguments, a linear extrapolation of

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[128] www.jorc.org/noncompliance.asp
[129] www.smh.com.au/business/golden-goose-lays-an-egg-20120322-1vmsz.html
[130] www.theage.com.au/business/big-miners-oppose-new-financial-disclosure-plan-20120607-1zyy1.html
[131] www.afr.com/p/business/companies/miners_reject_anti_corruption_reforms_NeBuguzm9PBMNjpsVvBPmK
[132] www.choosenuclearfree.net/uranium-exports/bubble/
[133] UNSCEAR, 2010, Report of the United Nations Scientific Committee on the Effects of Atomic Radiation on the Effects of Atomic Radiation 2010', www.unscear.org/docs/reports/2010/UNSCEAR_2010_Report_M.pdf
[134] US Committee on the Biological Effects of Ionising Radiation, US National Academy of Sciences, 2006, 'Health Risks from Exposure to Low Levels of Ionizing Radiation: BEIR VII Phase 2', www.nap.edu/books/030909156X/html

cancer risks from intermediate to very low doses currently appears to be the most appropriate methodology."[135]

If the Royal Commission wishes to dispute the near-consensus scientific position regarding radiation and health, that should be based on an equivalent weight of evidence and expertise as the inquiries that led the UNSCEAR and the BEIR Committee to conclude that there is no safe level of radiation exposure; i.e. a vast amount of evidence and expertise.

Demonstrating and quantifying the effects of low-dose, low dose rate exposure to ionising radiation becomes increasingly difficult at ever-lower doses. Yet − despite countless claims to the contrary − around 10 studies have shown effects for doses below 100 millisieverts (mSv).[136]

Uncertainties will always persist. In circumstances where people are exposed to low-level radiation, epidemiological studies are unlikely to be able to demonstrate a statistically-significant increase in cancer rates. Cancers are common diseases and most are multi-causal. Other complications include the long latency period for some cancers, and limited or uneven data on cancer incidence and mortality. The upshot is that cancer incidence and mortality statistics are being pushed up and down by a myriad of factors at any point in time and it becomes impossible or near-impossible to isolate any one factor.

While the overwhelming weight of scientific opinion holds that there is no threshold below which radiation exposure is harmless, there is less scientific confidence about how to quantify the risks. Typically, risk estimates are based on the Linear No Threshold (LNT) theory (0.1 fatal cancers per Sievert of exposure to low-dose, low dose rate ionising radiation) or LNT adjusted by a 'dose and dose rate effectiveness factor' (DDREF) to account for the possibility that LNT may overstate risks at low doses and dose rates. Thus a DDREF of 2 and a risk estimate of 0.05 fatal cancers per Sievert is commonly used. There are numerous other levels of complexity that are not addressed here, e.g. adjustments for gender, age, radiation type, body organ, diseases other than cancer, etc.

Another view is that the uncertainties at low doses and dose rates are so high that it is inappropriate to be estimating cancer deaths from data on collective radiation doses (from accidents, routine emissions, etc.). UNSCEAR and the International Commission on Radiological Protection recommend against using collective dose figures and risk estimates to estimate total deaths. The logical corollary of that position (or non-position) would be to state that there is an unknown cancer death toll from accidents, routine emissions, etc. − or more precisely an unknown death toll but one which is below the number that could be expected to yield statistically significant results in epidemiological studies (assuming such studies were carried out).

One problem with that position / non-position is that an unknown (or 'indiscernible') risk is often conflated with zero risk by nuclear lobbyists. Another problem is that there is usually no other way to estimate cancer death tolls (given the weakness of epidemiological studies in detecting radiation-related deaths given the high background incidence of and mortality from cancers). Indeed UNSCEAR itself has used LNT (with a DDREF) to estimate around 4,000 long-term cancer deaths among the people who received the highest radiation doses from Chernobyl.[137] It is important to keep in mind that UNSCEAR does not claim that low-level radiation exposure is harmless − as mentioned its 2010 report states that

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[135] David Brenner et al., 2003, 'Cancer risks attributable to low doses of ionizing radiation: Assessing what we really know', Proceedings of the National Academy of Sciences, November 25, 2003, vol.100, no.24, pp.13761–13766, www.ncbi.nlm.nih.gov/pubmed/14610281

[136] www.ianfairlie.org/news/a-100-msv-threshold-for-radiation-effects.

[137] The Chernobyl Forum: 2003–2005, 'Chernobyl's Legacy: Health, Environmental and Socio-Economic Impacts and Recommendations to the Governments of Belarus, the Russian Federation and Ukraine', Second revised version, p.16 www.iaea.org/Publications/Booklets/Chernobyl/chernobyl.pdf

"the current balance of available evidence tends to favour a non-threshold response for the mutational component of radiation-associated cancer induction at low doses and low dose rates."

To illustrate with the case of Fukushima, it is commonly claimed that the cancer death toll from radiation exposure will be 'indiscernible', i.e. epidemiological studies will not be able to demonstrate the radiation-related cancer death toll from Fukushima. The World Health Organization has found an uncomfortable middle ground, providing figures on elevated cancers risks for exposed populations (based on LNT) but without taking the logical next step of estimating the overall cancer death toll. The WHO report states that for people in the most contaminated areas in Fukushima Prefecture, the estimated increased risk for all solid cancers will be around 4% in females exposed as infants; a 6% increased risk of breast cancer for females exposed as infants; a 7% increased risk of leukaemia for males exposed as infants; and for thyroid cancer among females exposed as infants, an increased risk of up to 70% (from a 0.75% lifetime risk up to 1.25%).[138] However as mentioned the WHO does not translate those elevated risks into an estimate of the overall cancer death toll. (An LNT-based estimate of the death toll, based on UNSCEAR's collective dose estimate, is around 5,000 long-term cancer deaths from exposure to ionising radiation from Fukushima.[139])

While there is (and always will be) uncertainty with LNT at low doses and dose rates, it is important for the Royal Commission to note that **the true risks may be either higher or lower than LNT** − a point that needs emphasis and constant repetition because nuclear lobbyists routinely conflate uncertainty with zero risk. The BEIR report[140] states that "combined analyses are compatible with a range of possibilities, from a reduction of risk at low doses to risks twice those upon which current radiation protection recommendations are based." The BEIR report also states: "The committee recognizes that its risk estimates become more uncertain when applied to very low doses. Departures from a linear model at low doses, however, could either increase or decrease the risk per unit dose."

One final introductory point on radiation-related diseases: the risks are cumulative. To illustrate with the case of Fukushima, the internationally accepted dose limit for members of the public from anthropogenic sources of 1 millisievert (mSv) per year has been increased to 20 mSv p.a. in areas affected by Fukushima fallout (with moves to increase the level to 50mSv[141]). Thus a dose of up to 100 mSv over a five-year period is considered acceptable (by some). Assoc. Prof. Tilman Ruff gives some indication of the risks:[142]

"To provide a perspective on these risks, for a child born in Fukushima in 2011 who was exposed to a total of 100 mSv of additional radiation in its first five years of life, a level tolerated by current Japanese policy, the additional lifetime risk of cancer would be on the order of one in thirty, probably with a similar additional risk of premature cardiovascular death."

The cumulative nature of risks from radiation exposure undermines one of the furphies promulgated by nuclear apologists, some companies, and indeed by the Royal Commission itself with the implication in

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[138] WHO, 28 Feb 2013, 'Global report on Fukushima nuclear accident details health risks', www.who.int/mediacentre/news/releases/2013/fukushima_report_20130228/en/

[139] www.ianfairlie.org/news/new-unscear-report-on-fukushima-collective-doses/

[140] US Committee on the Biological Effects of Ionising Radiation, US National Academy of Sciences, 2006, 'Health Risks from Exposure to Low Levels of Ionizing Radiation: BEIR VII Phase 2', www.nap.edu/books/030909156X/html

[141] 22 May 2015, 'LDP wants to let evacuees move back to areas tainted with 50 millisieverts or less by March 2017', www.japantimes.co.jp/news/2015/05/22/national/ldp-team-calls-lifting-evacuation-orders-less-radiation-polluted-areas-march-2017/

[142] Tilman Ruff, 2013, 'A Public Health Perspective on the Fukushima Nuclear Disaster', *Asian Perspective*, 37, pp.523–549, www.mapw.org.au/files/downloads/AP37-4_Tilman%20Ruff%20%281%29.pdf

question 1.8 that there is a safe level of exposure to ionising radiation. The furphy is that doses below background levels are *ipso facto* safe. There is no scientific logic to that position as risks are cumulative.

Radon

In recent years the International Commission on Radiological Protection (ICRP) has upwardly revised its estimate of the carcinogenicity of radon. The latest ICRP evaluation of epidemiological studies of lung cancer risk from radon and radon progeny indicates that the risk is greater by approximately a factor of two than previously estimated.[143]

The ICRP's upwards revision of the hazards associated with radon exposure is clearly inconsistent with specious claims that the 'modern' view is that low-level radiation exposure is harmless.

ARPANSA has noted that the reassessment of the hazards associated with radon exposure "will have significant implications for the uranium industry worldwide, particularly for underground uranium mines."[144]

Leukemia

Also contradicting claims that the 'modern' scientific view is that low-level radiation exposure is harmless is recent research on radiation and leukemia.[145] Radiation biologist Dr Ian Fairlie provides the following plain-English summary:

> **Powerful new study shows radiogenic risks of leukemia 50% greater than previously thought**
> June 29, 2015
> www.ianfairlie.org/news/new-powerful-study-shows-radiogenic-risks-of-leukemia-50-greater-than-previously-thought/
> In 2013, I discussed several epidemiological studies providing good evidence of radiogenic risks at very low exposure levels.[146]
> A powerful new study (1) has been published in Lancet Haematology which adds to this evidence. However the study's findings are perhaps even more important than the previous studies, for several reasons.
> First, as stated by the authors, it provides "**strong evidence** of a dose-response relationship between cumulative, external, chronic, low-dose, exposures to radiation and leukaemia".
> Second, it finds radiogenic risks of leukemia among nuclear workers to be **50% greater** than previously thought. The excess relative risk of leukaemia mortality (excluding CLL) was 2·96 per Gy. In 2005, a similar study among nuclear workers in 15 countries by several of the same authors (2) found an ERR of 1·93 per Gy. Just as important, the new study's estimated risks are **much more precise** than before.

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[143] ICRP, 2010, 'Lung Cancer Risk from Radon and Progeny and Statement on Radon', ICRP Publication 115, Ann. ICRP 40(1), www.icrp.org/publication.asp?id=ICRP%20Publication%20115

[144] Prof. Peter Johnston, Acting CEO of ARPANSA, 14 Dec 2012, letter Z12020625, included in answers to Estimates Questions of Notice, Senate Community Affairs Committee, question e13-133.

[145] Leuraud, Klervi et al (2015) Ionising radiation and risk of death from leukaemia and lymphoma in radiation-monitored workers (INWORKS): an international cohort study. The Lancet Haematology Published Online: 21 June 2015. www.thelancet.com/journals/lanhae/article/PIIS2352-3026%2815%2900094-0/fulltext www.thelancet.com/pdfs/journals/lanhae/PIIS2352-3026(15)00094-0.pdf

[146] www.ianfairlie.org/news/recent-evidence-on-the-risks-of-very-low-level-radiation/

Third, it confirms risks even **at very low doses** (mean rate = 1·1 mGy per year). Unlike the Japanese bomb survivors' study, it actually observes risks at low dose rates rather than extrapolating them from high levels.
Fourth, it finds risks **do not depend on dose rate** thus contradicting the ICRP's use of a Dose Rate Effectiveness Factor (DREF) which acts to reduce (by half) the ICRP's published radiation risks.
Fifth, it finds radiogenic leukemia risks decline **linearly** with dose, contradicting earlier studies suggesting a lower, linear-quadratic relationship. It strengthens the Linear No Threshold model of radiogenic risks, as it now applies to leukemias as well as solid cancers.
Sixth, the study uses **90% confidence intervals and one-sided p-values**. In the past, 95% intervals and two-sided p-values were often incorrectly used which had made it harder to establish statistical significance.
Just as important are the study's credentials which are pretty impeccable. It's a huge study of over 300,000 nuclear workers adding up to over 8 million person years, thus ensuring its findings are statistically significant, ie with very low probability of occurring by chance. Also, it's an international study by 13 respected scientists from national health institutes in the US, UK, and France including
Centers for Disease Control and Prevention, US
National Institute for Occupational Safety and Health, US
Department of Health and Human Services, US
University of North Carolina, US
Drexel University School of Public Health, US
Public Health England, UK
Institut de Radioprotection et de Sûreté Nucléaire, France
Center for Research in Environmental Epidemiology, Spain
UN International Agency for Research on Cancer, France
Funding was provided by many institutions including US Centers for Disease Control and Prevention, US National Institute for Occupational Safety and Health, US Department of Energy, US Department of Health and Human Services, Japanese Ministry of Health Labour and Welfare, French Institut de Radioprotection et de Sûreté Nucléaire, and the UK's Public Health England.

Other Conclusions

This study powerfully contradicts the views of ill-informed and inexperienced journalists (including the UK writer, George Monbiot) and self-styled scientists who argue that radiation risks are over-estimated and even that radiation is somehow good for you. Hormetic effects are neither found nor discussed in this study: such irrelevant effects (if they exist) are regarded by real scientists as beneath consideration. The impressive list of contributing scientists and their national institutions here should serve to make radiation risk deniers rethink their views. This is particularly the case for US risk deniers, in view of the many US agencies and US scientists backing the study.
The authors pointedly comment that "*At present, radiation protection systems are based on a model derived from acute exposures, and assumes that the risk of leukaemia per unit dose progressively diminishes at lower doses and dose rates."* Their study shows this assumption is incorrect. The authors therefore join WHO and UNSCEAR scientists in their views that DREFs should not be used. The question remains whether the ICRP will accept this powerful evidence and scrap their adherence to using DREFs. I advise readers not to hold their breaths.
As regards the implications of their study, the authors interestingly choose to comment – not on exposures from the nuclear industry – but from medical exposures. They state *"Occupational and environmental sources of radiation exposure are important; however, the largest contributor to this trend is medical radiation exposure. In 1982, the average yearly dose of ionising radiation from medical exposures was about 0·5 mGy per person in the USA; by 2006, it had increased to 3·0 mGy. A similar pattern exists in other high-income countries: use of diagnostic procedures*

involving radiation in the UK more than doubled over that period and more than tripled in Australia. Because ionising radiation is a carcinogen, its use in medical practice must be balanced against the risks associated with patient exposure.
This is all correct and worrying, especially the revelation that medical radiation doses increased 6-fold in the US and doubled in the UK between 1982 and 2006. The authors add "*This finding shows the importance of adherence to the basic principles of radiation protection—to optimise protection to reduce exposures as much as reasonably achievable and—in the case of patient exposure—to justify that the exposure does more good than harm."*
The same, of course, applies to exposures from the nuclear industry – the actual subject of their research.

REFERENCES

(1) Leuraud, Klervi et al (2015) Ionising radiation and risk of death from leukaemia and lymphoma in radiation-monitored workers (INWORKS): an international cohort study. The Lancet Haematology Published Online: 21 June 2015.
(2) Cardis E et al (2005) Risk of cancer after low doses of ionising radiation: retrospective cohort study in 15 countries. BMJ 2005; 331:77.

Uranium, radiation and health

In a paper prepared for the Australian Uranium Association, Sydney University academic Manfred Lenzen states:
"According to the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), the global component from mill tailings is the most significant source of radiological exposure in the entire nuclear fuel chain. This holds irrespective of whether the 1993 or 2000 assessment is taken as a basis. Taking the higher estimate as more realistic, 150 Sv/GWe translate into 55.5 kSv globally, which is equivalent to an annual dose of about 0.01 mSv/capita if the entire world population were equally exposed. This estimate agrees well with ranges given in the assessment of uranium mines by Nilsson and Randhem 2008, who state a range of 0.1 to 0.001 mSv/cap."[147]

Using the above figure (55.5kSv) and using a risk estimate for exposure to low-level radiation of 0.05−0.1 cancer fatalities per Sievert, radiation exposure from uranium mine tailings is responsible for 2,775−5,550 deaths annually. A similar analysis is presented by nuclear physicist Richard Garwin.[148]

The following discussion on the topic of radiogenic effects from uranium mining is excerpted from a longer paper by Nuclear Radiologist Dr Peter Karamoskos[149]:

> *"The link between uranium mining and lung cancer has long been established. Certain groups of underground miners in Europe were identified as having increased mortality from respiratory disease as early as the 16th century. Lung cancer as the cause was not recognised until the 19th century. The radioactive gas, radon, was identified as the cause in the 1950's. Studies of underground miners, especially those exposed to high concentrations of radon, have consistently demonstrated the development of lung cancer, in both smokers and non-smokers. On this basis, the International Agency for Research on Cancer (IARC) classified radon as a carcinogen in 1988. In 2009, the ICRP stated that radon gas delivers twice the absorbed dose to humans as originally thought and hence is in the process of reassessing the permissible levels. Previous*

[147] Manfred Lenzen, 2009, 'Current state of development of electricity-generating technologies – a literature review', http://web.archive.org/web/20140124203606/http://aua.org.au/Content/Lenzenreport.aspx
Direct download http://web.archive.org/web/20140124203606/http://aua.org.au/DisplayFile.aspx?FileID=36
[148] Richard L. Garwin, 2001, 'Can the World Do Without Nuclear Power?', www.solarpeace.ch/solarpeace/Download/20010409_Garwin_NuclearPowerArticle.pdf
[149] Peter Karamoskos, 2010, 'Nuclear Power & Public Health', http://evatt.org.au/papers/nuclear-power-public-health.html

dose estimates to miners need to be approximately doubled to accurately reflect the lung cancer hazard.

"The Biological Effects of Ionising Radiation VI report (1999) reviewed eleven cohort studies of 60,000 underground miners with 2,600 deaths from lung cancer, eight of which were uranium mines in Europe, North America, Asia and Australia. These found a progressively increasing frequency of lung cancer in miners directly proportional to the cumulative amount of radon exposure in a linear fashion. Smokers had the highest incidence of lung cancer, as would be expected; however, the greatest increase in lung cancer was noted in non-smokers. The highest percentage increase in lung cancer was noted 5-14 years after exposure and in the youngest miners.

"Uranium miners are also exposed to IR [ionising radiation] directly from gamma radiation and the dose from this is cumulative to that from radon. At the Olympic Dam underground uranium mine, the total dose per miner is approximately 6mSv, of which 2-4 mSv (allowing for the new ICRP dose coefficients) are due to radon and the balance due to gamma radiation.

"Most modern uranium mines have air extraction systems and monitored ambient measures of radon concentrations to ensure levels remain low. Current levels of radon in underground uranium mines are only a fraction of mines over one hundred years ago. Furthermore, miners are given personal protective equipment (PPE) including masks to filter out the radioactive particulate matter. However, many underground miners find the masks extremely uncomfortable, especially in the hot underground environment they must contend with. It is estimated that up to 50% of underground uranium miners in Australia do not use their masks, and thus drastically increase their risk of lung cancer, whilst underestimating their actual radiation dose (since this is calculated assuming PPE's are used).

"The Olympic Dam doses mentioned above are typical of modern mine practices. The average miner at Olympic Dam is in his twenties and stays on average five years at the site. A typical calculation using the linear no threshold model and the latest BEIR-VII figures of radiation carcinogenesis risks indicates miners at Olympic Dam therefore have a 1:420 chance of contracting cancer, most likely lung cancer. Note that as the research demonstrates risk of developing lung cancer is greater for younger workers. These risks are not insubstantial. Radiation safety and risk principles can be quite complex and it is debatable whether miners have the training to understand the basis of such risks, or are even informed of these risks in a comprehensive and accurate manner that they can comprehend and make an informed work decision."

Recommendation 6: The Royal Commission should determine the extent and adequacy of usage of protective equipment including masks at underground uranium mines (currently limited to Olympic Dam in Australia).

Olympic Dam whistleblower

In 2010, a worker was sufficiently concerned about occupational health issues at Olympic Dam that he leaked information to the media [150] The leaked documents reportedly showed that BHP Billiton uses manipulated averages and distorted sampling to ensure its official figures of worker radiation exposure slip under the maximum permissible levels set by government. The BHP whistleblower said: "Assertions of safety of workers made by BHP are not credible because they rely on assumptions rather than, for example, blood sampling and, crucially, an assumption that all workers wear a respirator when exposed to highly radioactive polonium dust in the smelter."[151]

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[150] Hendrick Gout, 4 June 2010, 'Roxby's radioactive risk', Independent Weekly, www.archive.indaily.com.au/default.aspx?xml=mob&iid=36944#folio=008

[151] Hendrick Gout, 4 June 2010, 'Roxby's radioactive risk', Independent Weekly, www.archive.indaily.com.au/default.aspx?xml=mob&iid=36944#folio=008

Recommendation 7: The Royal Commission should investigate claims made by a BHP Billiton whistleblower in 2010 that the company uses manipulated averages and distorted sampling to ensure its official figures of worker radiation exposure fall under the maximum exposure levels set by government. The Royal Commission should also investigate the claim that radiation dose estimates are based on the assumption that all workers wear a respirator when exposed to polonium dust in the smelter.

In 2013, a Freedom of Information application revealed that the radiation plans for Olympic Dam were more than 15 years out of date. Between 2003 and 2012, BHP Billiton reported 31 radiation leaks at the mine. The Environment Protection Authority could only find plans from 1997 and 1998 and stated: "We acknowledge that an update is overdue and action is being taken to address this situation". The EPA searched its records for 10 months before responding that there was no up-to-date plan and it needed a new one. Greens MLA Mark Parnell said: "All these plans should be available in the public realm and not have to be chased using FOI application."[152]

The following article provides further information:

> *Radiation leak plan 15 years out of date*
> *Olympic Dam mine radiation leak plan 15 years out of date*
> *Miles Kemp, The Advertiser, 7 July 2013*
> *http://www.adelaidenow.com.au/business/olympic-dam-mine-radiation-leak-plan-15-years-out-of-date/story-fni6uma6-1226675659296*
> *THE radiation plans for Olympic Dam are more than 15 years out of date because of an administrative bungle, the Environment Protection Authority has revealed.*
> *The plans are needed because between 2003 and 2012, BHP-Billiton reported 31 radiation leaks at its Olympic Dam mine, totalling more than 3000 cubic metres of material, or the volume of a large hot-air balloon.*
> *Responding to a Freedom of Information application that exposed the problem, the EPA could only find plans from 1997 and 1998 and has stated: "We acknowledge that an update is overdue and action is being taken to address this situation".*
> *Greens MLC Mark Parnell said he sought a copy of the management plan to monitor how BHP-Billiton dealt with radiation leaks to protect workers and the environment.*
> *"Workers at Olympic Dam are at risk because the EPA and BHP-Billiton have failed to update their practices for over 15 years," he said.*
> *"What sort of oversight is there by the EPA at Olympic Dam when the basic management plan required under the National Code is ridiculously out of date?"*
> *The EPA searched its records for 10 months before responding that there was no up-to-date plan and it needed a new one.*
> *"All these plans should be available in the public realm and not have to be chased using FOI application," Mr Parnell said.*
> *He said there had been six triggers since 1998 that should have prompted an updated plan, including an expansion in the mine's capacity.*
> *"Between 1998 and 2013, an extraordinary amount of change has occurred in the regulation of radioactive material, with increasing awareness of the risks to workers and the natural environment and advances in processing," he said.*
> *The EPA's chief executive, Dr Campbell Gemmell, said safety had not been compromised but a new plan would be requested from BHP-Billiton.*
> *Environment Minister Ian Hunter said he would quiz the EPA on the status of the plans.*

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[152] Miles Kemp, 7 July 2013, 'Radiation leak plan 15 years out of date', www.adelaidenow.com.au/business/olympic-dam-mine-radiation-leak-plan-15-years-out-of-date/story-fni6uma6-1226675659296

A spokeswoman for BHP Billiton yesterday said its current radiation plan for Olympic Dam was reviewed and updated in December 2012 and has been submitted to the EPA for approval.
"While we work with the EPA to resolve administrative issues surrounding the approval process, Olympic Dam continues to operate strictly to this plan, the spokeswoman said.
"There has been no risk posed to the safety of workers at Olympic Dam or anyone beyond the site due to these administrative issues."
The Australian Radiation Protection and Nuclear Safety Agency requires that plans be regularly updated, to protect workers, the public and the environment.
The Advertiser revealed last month there are still 36 facilities used to store radioactive waste in SA, many in Adelaide suburbs, eight years after the State Government refused to allow a secure waste dump to be built in the Far North of the state.

On the basis of publicly-available information the outdated radiation plans would appear to represent a major failure not only of corporate governance but also of SA government oversight − not just an administrative issue as claimed by BHP Billiton.

Recommendation 8: The Royal Commission should investigate why BHP Billiton's radiation plans were seriously outdated and why the SA government did not act to rectify the problem. The Royal Commission should seek further detail into what steps SA agencies have taken to address these deficiencies and enhance transparency.

Polonium exposure at Olympic Dam

Greens MLC Mark Parnell, drawing on FoI documents, has raised concerns about radiation exposure at Olympic Dam and possibly inadequate reporting requirements.

The relevant media release is copied here:

Govt failing Roxby workers over radiation risk: Greens
SA Greens MLC Mark Parnell, 19/06/2008, Media Release,
http://markparnell.org.au/mr.php?mr=502
Greens MLC Mark Parnell has accused the Rann Government of failing to adequately protect workers exposed to dangerous radiation levels at Olympic Dam.
Documents obtained under Freedom of Information show a poor level of monitoring of radioactive polonium airborne dust. Polonium, a particularly toxic and dangerous radioactive substance, was dramatically used to assassinate Russian defector Ivan Litvinenko in London in Nov 2006.
Despite the significant risk to workers of exposure to polonium, the Radiation Protection branch of the Environment Protection Authority agreed to reduce BHP Billiton's reporting requirements in 2006. Since then, the number of reports of workers exposed to unsafe levels of radiation has plummeted, despite no change occurring to production processes at the plant, raising serious questions about the level and type of testing currently undertaken by the company.
"The Government is failing in their duty to adequately monitor and protect the health of workers at Olympic Dam," said Mr Parnell.
"Documents I have obtained through FoI, after much struggle, raise serious concerns about how often testing occurs. For example: sampling of airborne radiation levels is not done when workers are at greatest risk, and personal radiation monitoring devices, that often record readings above the allowable level, are only worn part of the time by some, not all, exposed workers.
"The uranium industry likes to spruik how safe their industry is. If that is the case, why are they so cagey about releasing occupational health and safety information?

"The Government should be asking tough questions about whether enough testing, at the right time, is being done by BHP Billiton. I sincerely hope that the Government and the company are prepared to aggressively test for radiation exposure, even if it throws up inconvenient truths. "The Rann Government must match its gung-ho support of the uranium industry with adequate protection for workers," he said.

See also the information posted at:
http://markparnell.org.au/results.php?q=polonium&Submit.x=0&Submit.y=0

Recommendation 9: The Royal Commission should investigate FoI-based claims by MLC Mark Parnell regarding polonium exposure and reporting requirements at Olympic Dam.

Uranium companies promote dangerous radiation junk science

In May 2012, 48 Australian medical practitioners signed the following statement calling on Toro Energy to stop promoting dangerous radiation junk science:

Toro Energy is an Australian company involved in uranium exploration in Western Australia, the Northern Territory, South Australia and in Namibia, Africa. The company's most advanced project is the proposed Wiluna uranium mine in the WA Goldfields.

Toro Energy has consistently promoted the fringe scientific view that exposure to low-level radiation is harmless. Toro Energy has sponsored at least three speaking visits to Australia by Canadian scientist Dr Doug Boreham, who argues that low-level radiation is actually beneficial to human health.

Those views are at odds with mainstream scientific evidence and expert assessment. For example:

- *A 2010 report by the United Nations Scientific Committee on the Effects of Atomic Radiation states that "the current balance of available evidence tends to favour a non-threshold response for the mutational component of radiation-associated cancer induction at low doses and low dose rates."*
- *The 2006 report of the Committee on the Biological Effects of Ionising Radiation (BEIR) of the US National Academy of Sciences states that "the risk of cancer proceeds in a linear fashion at lower doses without a threshold and ... the smallest dose has the potential to cause a small increase in risk to humans." The report also concludes that claims that low-level radiation exposure may be beneficial to human health are "unwarranted".*
- *A review published in the Proceedings of the National Academy of Sciences (US) in 2003 concluded that: "Given that it is supported by experimentally grounded, quantifiable, biophysical arguments, a linear extrapolation of cancer risks from intermediate to very low doses currently appears to be the most appropriate methodology."*

It is irresponsible for Toro Energy to consistently promote fringe scientific views and to ignore mainstream scientific evidence and expert assessment.

Even more alarming is that Toro Energy has sponsored "employee radiation training" by Dr Boreham. Recent scientific research has heightened concern about exposure to radon, the main source of radiation doses to uranium industry workers. In 2009, the International Commission on Radiological Protection concluded that radon gas delivers almost twice the radiation dose to humans as originally thought and the Commission is in the process of reassessing permissible levels. Previous dose estimates to miners need to be approximately doubled to accurately reflect the lung cancer hazard.

We call on Toro Energy to stop promoting fringe scientific views to uranium industry workers and to the public at large.

A similar doctors' statement was signed by 39 Australian medical practitioners in 2014 questioning Cameco's decision to sponsor speaking events by Boreham.[153]

In 2008 Boreham visited Australia to work with Toro Energy, Uranium One and Heathgate Resources in the area of employee radiation training and community consultation on radiation and uranium.[154]

In 2010, Boreham spoke at a 'Radiation Information Seminar' in Adelaide which was co-hosted by the Australian Uranium Association and Toro Energy.[155]

BHP Billiton and Rio Tinto were sponsors of a 2011 conference which included Boreham on the speaking platform − with no speakers presenting the mainstream scientific understanding of radiation/health.[156]

Thus many of the uranium companies in Australia have been actively promoting views directly at odds with the consensus / near-consensus scientific position that there is no safe level of exposure to ionising radiation. ARPANSA (and equivalent state/territory bodies) could and should take a proactive role promoting established science to counter the self-serving promotion of fringe views by uranium companies.

Recommendation 10: Uranium company representatives should explain to the Royal Commission why they have promoted self-serving contrarian views regarding radiation and health instead of promoting the accepted scientific understanding that there is no safe level of exposure to ionising radiation.

One wonders what sort of 'employee radiation training' Boreham has provided to workers at Australian uranium mines (and uranium exploration sites). Presumably the advice is that employees should make little or no effort to protect themselves against exposure to ionising radiation. Perhaps the advice is that workers should take steps to increase their exposure (in line with the fringe view that low level radiation exposure is beneficial to human health). Either way, the advice is at odds with established science and the Royal Commission needs to investigate this issue.

Recommendation 11: The Royal Commission should investigate the use of Doug Boreham by some uranium companies to provide 'employee radiation training'. Are Boreham and uranium companies encouraging practices at odds with established OH&S advice and recommendations?

NFCRC Issues Paper #1 states that "workers who deal with these [radioactive] substances must be provided with information about any potential hazards prior to commencing work and be provided with personal protective equipment which is specifically designed to protect against radiation exposure."

Recommendation 12: The Royal Commission should determine whether the provision of contrarian advice at odds with mainstream scientific opinion meets the legislative and regulatory requirements for the provision of advice on radiological workplace hazards in SA.

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[153] www.mapw.org.au/news/cameco-stop-promoting-radiation-junk-science
[154] Toro Energy, 2008, Radiation Information Seminar, www.ausimm.com.au/Content/wir/doug_boreham_invit.pdf
[155] www.ausimm.com.au/content/docs/adelaide_news_apr10.pdf
[156] www.aioh.org.au/conference/2011/presenters.html

Recommendation 13: The Royal Commission should determine whether the provision of personal protective equipment is sufficient or if there is (or should there be) a requirement for workers to actually use protective equipment?

Case study of the radiation/health debates: the Chernobyl death toll

The debate over the Chernobyl death toll can be used to illustrate the debates over radiation and health.

About 50 people died in the immediate aftermath of the Chernobyl accident. Beyond that, studies generally don't indicate a significant increase in cancer incidence in populations exposed to Chernobyl fallout. Nor would anyone expect them to because of the data gaps and methodological problems mentioned earlier, and because the main part of the problem concerns the exposure of millions of people to low doses of radiation from Chernobyl fallout.

For a few fringe scientists and nuclear industry insiders and apologists, that's the end of the matter − the statistical evidence is lacking and thus the death toll from Chernobyl was just 50. (They should − but generally don't − note an additional, unknown death toll from cancer and from other radiation-linked diseases including cardiovascular disease.

We can still arrive at a scientifically defensible estimate of the Chernobyl death toll by using estimates of the total radiation exposure, and multiplying by an appropriate risk estimate. The International Atomic Energy Agency estimates a total collective dose of 600,000 person-Sieverts over 50 years from Chernobyl fallout.[157] Applying the LNT risk estimate of 0.10 fatal cancers per Sievert gives an estimate of 60,000 deaths. Sometimes a risk estimate of 0.05 is used to account for the possibility of decreased risks at low doses and/or dose rates (in other words, 0.05 is the risk estimate when applying a 'dose and dose rate effectiveness factor' or DDREF of two). That gives an estimate of 30,000 deaths. The US BEIR committee notes that true risks may be higher or lower than LNT − so the death toll may exceed 60,000.

A number of studies apply that basic method − based on collective radiation doses and risk estimates − and come up with estimates of the Chernobyl cancer death toll varying from 9,000 (in the most contaminated parts of the former Soviet Union) to 93,000 deaths (across Europe).

UN reports in 2005-06 estimated up to 4,000 eventual deaths among the higher-exposed Chernobyl populations (emergency workers from 1986−1987, evacuees and residents of the most contaminated areas) and an additional 5,000 deaths among populations exposed to lower doses in Belarus, the Russian Federation and Ukraine.[158]

The estimated death toll rises further when populations beyond those three countries are included. For example, a study by Cardis et al reported in the International Journal of Cancer estimates 16,000 deaths.[159] Dr Elisabeth Cardis, head of the Radiation Group at the World Health Organization's International Agency for Research on Cancer, said: "By 2065 (i.e. in the eighty years following the

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[157] IAEA, 1996, "Long-term Committed Doses from Man-made Sources," IAEA Bulletin, Vol.38, No.1, http://foe.org.au/sites/default/files/Chernobyl%20600k%20p-Sv%20IAEA%20Bull.pdf

[158] Chernobyl Forum, 2005, 'Chernobyl's Legacy: Health, Environmental and Socio-Economic Impacts', www.iaea.org/Publications/Booklets/Chernobyl/chernobyl.pdf
World Health Organization, 2006, www.who.int/mediacentre/news/releases/2006/pr20/en/index.html
www.who.int/ionizing_radiation/chernobyl/backgrounder/en/

[159] Cardis E, Krewski D, Boniol et al, 'Estimates of the Cancer Burden in Europe from Radioactive Fallout from the Chernobyl', International Journal of Cancer, Volume 119, Issue 6, pp.1224-1235, Published Online: 20 April 2006, www.ncbi.nlm.nih.gov/pubmed/16628547
http://onlinelibrary.wiley.com/doi/10.1002/ijc.22037/pdf

accident), predictions based on these models indicate that about 16,000 cases of thyroid cancer and 25,000 cases of other cancers may be expected due to radiation from the accident and that about 16,000 deaths from these cancers may occur. About two-thirds of the thyroid cancer cases and at least one half of the other cancers are expected to occur in Belarus, Ukraine and the most contaminated territories of the Russian Federation."[160]

UK radiation scientists Dr Ian Fairlie and Dr David Sumner estimate 30,000 to 60,000 deaths.[161] Radiation biologist Ian Fairlie notes that recent statements by UNSCEAR indicate that it believes the whole body collective dose across Europe from Chernobyl was 320,000 to 480,000 Sv, from which an estimate of 32,000 to 48,000 fatal cancers can be deduced (using the LNT risk estimate of 0.10).[162]

According to physicist Dr. Lisbeth Gronlund: "53,000 and 27,000 are reasonable estimates of the number of excess cancers and cancer deaths that will be attributable to the accident, excluding thyroid cancers. (The 95% confidence levels are 27,000 to 108,000 cancers and 12,000 to 57,000 deaths.) In addition, as of 2005, some 6,000 thyroid cancers and 15 thyroid cancer deaths have been attributed to Chernobyl. That number will grow with time. Much lower numbers of cancers and deaths are often cited, but these are misleading because they only apply to those populations with the highest radiation exposures, and don't take into account the larger numbers of people who were exposed to less radiation."[163]

A 2006 expert report commissioned by Greenpeace estimates a cancer death toll of about 93,000.[164] According to Greenpeace:
"Our report involved 52 respected scientists and includes information never before published in English. It challenges the UN International Atomic Energy Agency Chernobyl Forum report, which predicted 4,000 additional deaths attributable to the accident as a gross simplification of the real breadth of human suffering. The new data, based on Belarus national cancer statistics, predicts approximately 270,000 cancers and 93,000 fatal cancer cases caused by Chernobyl. The report also concludes that on the basis of demographic data, during the last 15 years, 60,000 people have additionally died in Russia because of the Chernobyl accident, and estimates of the total death toll for the Ukraine and Belarus could reach another 140,000."

Those are the credible estimates of the eventual death toll from Chernobyl. Another defensible position (or non-position) is that the long-term cancer death toll is unknown and unknowable because of the uncertainties associated with the science. Unqualified claims that the death toll from Chernobyl was just 50 are common but baseless. Quantifying the long-term cancer death toll is difficult but expert scientific opinion holds that there certainly has been − and will be − deaths from long-term radiation exposure from Chernobyl fallout. As the WHO has noted: "An increased number of cancer deaths can be expected during the lifetime of persons exposed to radiation from the [Chernobyl] accident."[165]

The following article provides some insight into the politics surrounding the science:

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[160] Cardis, Elizabeth, 2006,
www.iarc.fr/en/media-centre/pr/2006/pr168.html
[161] Ian Fairlie and David Sumner, 2006,' The Other Report on Chernobyl',
www.chernobylreport.org
[162] www.ianfairlie.org/news/new-unscear-report-on-fukushima-collective-doses/
[163] Lisbeth Gronlund, 17 April 2011, 'How Many Cancers Did Chernobyl Really Cause?',
http://allthingsnuclear.org/post/4704112149/how-many-cancers-did-chernobyl-really-cause-updated
[164] Greenpeace, 2006, 'The Chernobyl Catastrophe − Consequences on Human Health',
www.greenpeace.org/international/en/publications/reports/chernobylhealthreport/
www.greenpeace.org/international/Global/international/planet-2/report/2006/4/chernobylhealthreport.pdf
[165] WHO, April 2006, 'Health effects of the Chernobyl accident: an overview',
www.who.int/ionizing_radiation/chernobyl/backgrounder/en/

Contentious Calculation

Controversy over Chernobyl's future cancer toll

By John Dudley Miller

Scientific American 295, pp.29-30, October 2006

www.scientificamerican.com/article/contentious-calculation/

The Chernobyl nuclear plant in Ukraine exploded 20 years ago, but the disaster will continue for another 60 years in the form of slow deaths from cancers. The accident released a plume that dropped radioactive particles throughout the Northern Hemisphere. No one has pinned down the expected toll—estimates range from thousands to tens of thousands, revealing disagreements in the way the figures should be calculated and limitations in current knowledge about radiation damage.

The most commonly reported figure is 4,000 deaths, which derives from a 2005 United Nations press release. Curiously, it called the 4,000 a "new" number from a study by "an international team of more than 100 scientists"—even though the cited work was from 1996 and was authored by only seven scientists. "Certainly the 1996 paper was never meant to make the headlines of the newspapers 10 years later," remarks lead author Elisabeth Cardis of the World Health Organization's International Agency for Research on Cancer in Lyon, France.

Stranger still, the 1996 study had estimated 9,000 deaths, not 4,000. "It was either a deliberate omission or a simply outrageous error," says David Marples, a historian at the University of Alberta who has written several books about Chernobyl. "In either case, it is not scientifically acceptable." Keith Baverstock, the former head of the European office of the WHO's radiation protection division, calls it "scientifically unacceptable" as well as "selective and misleading."

A staffer at the International Atomic Energy Agency (IAEA) strongly disagreed, arguing that both the IAEA and the WHO believe that 4,000 is correct, because the calculation for the additional 5,000 is so uncertain that both organizations "considered it insignificant." But a WHO spokesperson says that to correct "the imprecisions" of the 2005 U.N. release, the organization issued a statement in April announcing that "there may be up to 9,000 excess deaths due to Chernobyl." The IAEA's charter "to accelerate" the expansion of nuclear power worldwide biases it "toward underreporting Chernobyl deaths," says Robert Alvarez, a former Department of Energy senior policy adviser.

Still, 9,000 deaths may be a vast underestimate. Cardis had confined her 1996 analysis to contaminated areas of Ukraine, Belarus and western Russia.

Sixty-four percent of Chernobyl's radiation fell outside the former Soviet Union, according to a 1988 U.N. report.

This past April, Cardis and a new team extended the original study to all of Europe. On top of 2,200 cleanupworker deaths the 1996 study estimated, they predict that through 2065 another 6,700 to 38,000 European residents (with a "best guess" of 16,000) might succumb to Chernobyl-caused cancers.

Other calculations, including one by Baverstock and another by the European Green Party, peg the worldwide death toll at 30,000 to 60,000.

Chernobyl death estimates are also controversial because they are based on data from survivors of the 1945 atomic bombings of Japan. Those individuals received large doses all at once; Chernobyl exposed people to small, continuous doses for years. Uncertainty about the exact amounts of radiation that the Japanese victims received has contributed to the broad ranges in Chernobyl estimates. Also, some investigators believe that any amount of radiation, no matter how small, harms the body and that the damage is proportional to the dosage.

Others think that a threshold exists below which radiation is harmless.

A threshold effect suggests that the estimates of tens of thousands of deaths, from calculations that assume that harm is linearly proportional to dosage, are well off the mark. "They're not people," remarks Antone Brooks, a radiation biologist at Washington State University.

"They're numbers generated from a hypothesis." Brooks believes a threshold exists, so he thinks that the IAEA was correct to drop the 5,000 predicted deaths in less contaminated areas. Who is right in the Chernobyl guesstimate game may never be known. Cancer kills one out of every four people, meaning that about 117 million Europeans will die of non-Chernobyl cancers through 2065, Cardis remarks. So even though the nuclear accident may ultimately cause many thousands of deaths, Chernobyl cancers will, unfortunately, be impossible to detect. John Dudley Miller, a writer based in Cleveland, was a U.S. Navy submarine nuclear engineering officer.

1.9 Are the existing arrangements for addressing the interaction between the interests of exploration and extraction activities and other groups with interests such as landowners and native title holders suitable to manage an expansion in exploration or extraction activities? Why? If they are not suitable, what needs to be done?

Introduction

Our organisations hold serious concerns over past and continuing nuclear industry practices and impacts and the following comments highlight the often poor treatment of Aboriginal people by the nuclear/uranium industries in Australia and by governments pursuing or facilitating nuclear/uranium projects.

Most of the issues discussed here are either current or they are recent history. There are patterns of mistreatment that will likely be exacerbated by any Royal Commission recommendations to expand the uranium/nuclear industry − unless proactive measures are put in place to empower and protect Aboriginal people.

Recommendation 14: The Royal Commission should recommend against any further uranium/nuclear developments until such time as:

- Laws exempting the uranium industry from Aboriginal heritage protection laws are repealed.
- Maralinga is cleaned up adequately.
- There have been independent inquiries into the mistreatment of Aboriginal people in relation to attempts to establish national nuclear waste facilities in SA (1998−2004) and the NT (2005−2014), and mechanisms put in place to prevent further such adverse processes and impacts.
- The use of divide and rule tactics by uranium companies against Aboriginal people is investigated and mechanisms put in place to prevent such tactics being deployed in future.
- Aboriginal land owners are afforded an effective veto provision over proposed mining and wider nuclear industry developments on their lands.

Maralinga

The British government conducted 12 nuclear bomb tests in Australia in the 1950s, most of them at Maralinga. The 1985 Royal Commission found that regard for Aboriginal safety was characterised by "ignorance, incompetence and cynicism".[166]

In the late-1990s, the Australian government carried out a clean-up of the Maralinga nuclear test site.[167] It was done on the cheap and many tonnes of plutonium-contaminated debris remain buried in shallow,

[166] www.foe.org.au/anti-nuclear/issues/oz/britbombs/

unlined pits in totally unsuitable geology. The government said the Maralinga clean-up was 'world's best practice' even though it breached Australian standards for the management of long-lived nuclear waste − specifically, Australian standards preclude the shallow burial of long-lived waste.[168] ARPANSA also promoted the fiction that the clean-up was 'world's best practice'.

Nuclear engineer and whistleblower Alan Parkinson said of the 'clean-up': "What was done at Maralinga was a cheap and nasty solution that wouldn't be adopted on white-fellas land."[169]

Scientist and whistleblower Dale Timmons said the government's technical report was littered with "gross misinformation".[170]

Geoff Williams, an officer with the Commonwealth nuclear regulator ARPANSA, said that the 'clean-up' was beset by a "host of indiscretions, short-cuts and cover-ups".[171]

Nuclear physicist Prof. Peter Johnston (now with ARPANSA) noted that "there were ... very large expenditures and significant hazards resulting from the deficient management of the project by DEST [the Department of Education, Science and Training]."[172]

Prof. Johnston also commented on plans for a national repository in SA (from 1998−2004): "DEST is responsible for the Former Nuclear Test site at Maralinga, as well as the Repository project. DEST was an ineffective manager of the Maralinga Cleanup in a number of key ways. The pattern of contracting ... services for the Repository project is similar to the Maralinga cleanup. ... The applicant has inadequate technical competence to manage its contractors."[173]

Prof. Johnston (and others) noted in a detailed paper prepared for an IAEA conference that Traditional Owners were excluded from any meaningful input into decision-making concerning the clean-up:[174]

"The Australian Government responded to these [Royal Commission] recommendations by forming in February 1986, a Technical Assessment Group (TAG) to address the technical conclusions stemming from the Royal Commission and a Consultative Group was formed as a forum for discussion of the program. TAG's task was to provide the Australian Government with options for rehabilitation rather than a recommendation. Membership of the Consultative Group was as envisaged by the Royal Commission for the Maralinga Commission but with additional representatives of the West Australian Government. Notably this structure which formed the basis for the entire rehabilitation project left the traditional owners and the South Australian Government out of direct decision making. It ensured that real authority remained with bureaucrats within the Department of Primary Industries and Energy

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[167] Detailed information, including material from whistleblowers, is posted at: www.foe.org.au/anti-nuclear/issues/oz/britbombs/clean-up

[168] www.foe.org.au/sites/default/files/ParkinsonARPANSA2004.doc

[169] ABC Radio, Aug 2002. A number of Mr Parkinson's papers and submissions are posted at www.foe.org.au/anti-nuclear/issues/oz/britbombs/clean-up. See also Alan Parkinson, 2015 submission to Nuclear Fuel Cycle Royal Commission, http://nuclearrc.sa.gov.au/app/uploads/2015/08/Alan-Parkinson-12-06-2015.pdf

[170] http://pandora.nla.gov.au/pan/30410/20090218-0153/www.geocities.com/jimgreen3/martac.html

[171] ABC Background Briefing, 16 April 2000, 'Maralinga: The Fall Out Continues', www.abc.net.au/radionational/programs/backgroundbriefing/maralinga-the-fall-out-continues/3466242

[172] 2004, Submission to ARPANSA inquiry into proposed repository in SA, www.foe.org.au/anti-nuclear/issues/oz/britbombs/clean-up

[173] 2004, Submission to ARPANSA inquiry into proposed repository in SA, www.foe.org.au/anti-nuclear/issues/oz/britbombs/clean-up

[174] P.N. Johnston, A.C. Collett, T.J. Gara, "Aboriginal participation and concerns throughout the rehabilitation of Maralinga", presented at the Third International Symposium on the Protection of the Environment from Ionising Radiation, Darwin, 22-26 July 2002. See pp.349-56 in this PDF: www-pub.iaea.org/MTCD/publications/PDF/CSP-17_web.pdf

which obtained advice from TAG and later the Maralinga Rehabilitation Technical Advisory Committee (MARTAC)."

Traditional Owners were represented on a 'consultative committee' but key decisions − such as abandoning vitrification of plutonium-contaminated waste in favour of shallow burial in unlined trenches − were taken without any consultation with the 'consultative committee' or any separate discussions or consultations with Traditional Owners.[175]

Senator Nick Minchin said in a May 1, 2000 media release that: "As the primary risk from plutonium is inhalation, all these groups have agreed that deep burial of plutonium is a safe way of handling this waste." By "these groups" the Minister meant ARPANSA, the Maralinga Tjarutja and South Australian Government. The Minister's statement was false on two counts. Firstly, the burial of plutonium-contaminated debris is not 'deep' no matter how loose the definition − the soil cover was just five metres. Secondly, the Maralinga Tjarutja certainly did not agree to the decision to abandon ISV in favour of burial − in fact they wrote to the Minister disassociating themselves from the decision.[176]

The Senate passed resolutions condemning the clean-up on 21 August 2002 and 15 October 2003.[177]

Barely a decade after the Maralinga 'clean-up', a survey revealed that 19 of the 85 contaminated debris pits have been subject to erosion or subsidence.[178]

Despite the contamination, the federal government off-loaded responsibility for the land onto the Maralinga Tjarutja Traditional Owners. The government portrayed this land transfer as an act of reconciliation. But it wasn't an act of reconciliation − it was deeply cynical. The real agenda was spelt out in a 1996 government document which stated: "The project is aimed at reducing Commonwealth liability arising from residual contamination."

The following presentation by nuclear engineer Alan Parkinson highlights some of the problems:

> *Maralinga − Australia's nuclear waste cover-up*
> *Ockham's Razor − ABC Radio National*
> *September 2, 2007*
> *www.abc.net.au/rn/ockhamsrazor/stories/2007/2019647.htm#transcript*
>
> *Robyn Williams: Isn't it fascinating to contemplate how the world changes. Twenty-five years ago we saw the first CDs replace those large vinyl discs we used to call LPs. Fifty years ago the space age really began with the launch of Sputnik, the first satellite, followed by Laika the dog. And at about the same time, out in the desert in South Australia, the British were exploding bombs, atomic bombs, something that may come as a surprise to younger listeners. Alan Parkinson has written a book about all this and about what happened next. It's called 'Maralinga, Australia's Nuclear Waste Cover-up'.*
>
> *Alan Parkinson:*
> *Most people living in Australia today probably do not know that twelve atomic bombs have been exploded on Australian territory.*

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[175] P.N. Johnston, A.C. Collett, T.J. Gara, "Aboriginal participation and concerns throughout the rehabilitation of Maralinga", presented at the Third International Symposium on the Protection of the Environment from Ionising Radiation, Darwin, 22-26 July 2002. See pp.349-56 in this PDF: www-pub.iaea.org/MTCD/publications/PDF/CSP-17_web.pdf

[176] Senate Estimates, May 3, 2000.

[177] www.foe.org.au/anti-nuclear/issues/oz/britbombs/clean-up

[178] www.theage.com.au/national/maralinga-sites-need-more-repair-work-files-show-20111111-1nbpp.html

Seven of those bombs were exploded at Maralinga, in South Australia, in the 1950s. Following those explosions, Britain conducted a series of experiments in which they exploded another 15 bombs in a manner which precluded an atomic explosion. Those experiments spread plutonium and uranium over hundreds of square kilometres of the South Australian landscape.
Before they abandoned the site, the British conducted a final clean-up in 1967, and the Australian government accepted their assurance that Maralinga was clean. In the mid 1980s, scientists from the Australian Radiation Laboratory surveyed the site and found it was far from satisfactory.
In 1989, I prepared estimates for some 30 options for cleaning the site, ranging from simply fencing the contaminated area to scraping over 100 square kilometres of land and burying the contaminated soil. The Federal government agreed with the South Australian government and the Maralinga Tjarutja to implement a partial clean-up.
This partial clean-up was to be in two parts: the first was to scrape up and buy the most contaminated soil. The second part was to treat 21 pits containing thousands of tonnes of plutonium-contaminated debris by a process of vitrification, which would immobilise the plutonium for perhaps a million years.
In 1993, I was appointed a member of the Maralinga Rehabilitation Technical Advisory Committee whose purpose was to advise the Minister on progress of the project, and a few months later, I was appointed the government's representative to oversee the whole project.
By the end of 1997, the collection and burial of contaminated soil was nearing an end. However, as that soil was scraped up, we found the state of the 21 debris pits was not at all what we had been led to believe from the British reports.
The pits were very much larger than the British reports told us, with about three times as much debris as we had expected, and therefore treatment by vitrification would clearly cost a lot more.
By then we had completed a three-year program to match the vitrification technology to the Maralinga geology, and a company called Geosafe had built the equipment ready to use it to treat the pits. Unfortunately, when the department signed the contract with Geosafe, they failed to include that most basic feature of any contract: a statement of what had to be achieved.
The equipment was tested in Adelaide before being taken to site, and those tests, which I witnessed, showed that the technology was going to be just as successful as we had hoped.
It was at this time that the department held three meetings with a company that had no knowledge at all of the vitrification technology; they had not been involved in the three-year development program, and nobody from that company had even seen the full-size equipment. Similarly, the two attendees from the department had no knowledge of the technology, or any project management experience. Add to that, nobody in those meetings had any nuclear expertise or experience in the disposal of nuclear waste.
Even though I was the government's representative overseeing the whole project, I was excluded, as was Geosafe.
The department then proposed to appoint this company as project manager and project authority over the vitrification part of the project. I resisted this and advised them not to proceed along this path. Geosafe also objected, telling the department several times in writing and face-to-face that the company was not qualified to take over the project, having no knowledge at all of what was involved. The department persisted and against all advice, appointed the company. For my pains I was removed from the project and the advisory committee. I was sacked.
So the world's experts in the vitrification technology found themselves contracted to the department but reporting to a company that knew nothing about the technology. In turn, that company reported to people in the department who were similarly ignorant of the technology, had no nuclear expertise and no project management experience. From that point on, the project was almost certainly likely to fail.
Within a few weeks of being appointed, the new project managers put forward a proposal that some of the pits should be exhumed and their contents buried, claiming this would be cheaper. The department accepted the suggestion and introduced what they called the hybrid system, a

mixture of dubious practice and the best available technology. And I maintain they did this merely to save money, in fact later when Mr Peter McGauran inherited the project, he tried to defend the saving of over $5-million.
Vitrification of some pits continued until, as treatment was nearing completion on one pit, there was a huge explosion within the pit. The steel hood over the pit was extensively damaged, and molten glass was spewed some 50 metres from the pit. Fortunately, nobody was injured in the incident, but it gave the government an excuse to cancel vitrification altogether.
They then exhumed all the pits, including those that had been vitrified, and placed the whole lot in a shallow grave and covered it.
In March 2000, Senator Minchin visited Maralinga and declared the site was safe, and could be returned to the Aborigines. He was accompanied on that visit by Dr John Loy, the Head of the Australian Radiation Protection and Nuclear Safety Agency, ARPANSA.
Dr Loy went on to claim that the shallow burial of plutonium contaminated debris was world's best practice. Three years later, on 25th March, 2003, Mr McGauran tabled the government's final report of the project in parliament. In his speech, he said, 'The project achieved its goals and a world best practice result', oblivious to the fact that a partial clean-up cannot, by definition, be world's best practice.
It would be a pity if the only record of the project was that published by the government. That final report contains so many incorrect statements that it cannot be said to describe what really happened on the project.
And now, seven years after the government claimed the project a success and four years after Mr McGauran's declaration, it is time to put a few things into perspective and look back on how the project was managed and what it bodes for the future.
In this I am mindful of the Prime Minister's push towards nuclear power. Dr Switkowski's inquiry drew attention to three things that are relevant to the Maralinga project.
The first is for there to be an independent nuclear regulator. The Maralinga project was half way through its final phase when ARPANSA was born.
The second is the need to recruit scientists and engineers with experience in the nuclear industry. The last phase of the Maralinga project was managed by a company with no nuclear expertise, reporting to a client similarly devoid of nuclear experiences, and in some cases, no technical knowledge.
And the third is the problem of nuclear waste disposal. The Minister and the Chief Nuclear Regulator claim the shallow burial of plutonium to be world's best practice. So why does the rest of the world not follow suit? Why do they insist that long-lived nuclear waste, such as that at Maralinga, should be disposed of in a deep geological facility?
In August 2003, I visited Sellafield in Northern England; that is where the plutonium now spread over a huge area of South Australia originated. There, people with far more experience in dealing with plutonium place plutonium-contaminated material in stainless steel drums and store those drums in an airconditioned building on a guarded site, awaiting permanent deep geological disposal.
It is the same story in America where trials similar to those at Maralinga were conducted, except on a much smaller scale. In their clean-up, the Americans bagged the contaminated soil and debris and transported the whole lot over 300 kilometres to a nuclear waste storage facility on a guarded site.
Those countries clearly do not agree that burial of plutonium in a shallow grave with no packaging and in totally unsuitable geology is world's best practice.
In July 2001, the government published a document called 'Safe Storage of Radioactive Waste' which says that long-lived low and intermediate level waste is not suitable for shallow burial.
And yet that is what has been done at Maralinga and claimed to be world's best practice.
And the government puts similar spin on other features of the project.
In his speech to Parliament Mr McGauran said the clean-up would 'permit unrestricted access to about 90% of the 3,200 square kilometre Maralinga site'. But there was unrestricted access to

90% of the site before the project started. The only additional area in which there is unrestricted access is half a square kilometre. Admittedly another 1.6 square kilometres have been cleaned, but that is within the area to which access is restricted. And one part of that restricted area is 300 times more contaminated than the clean-up criteria.
In truth, after spending $108-million, less than 2% of the land contaminated above the clean-up criteria has been cleaned. I am not criticising that, it was what was planned, but let us keep it in perspective.
Anybody listening to the government's statements might be under the impression that the whole site is now clean and all the plutonium used in those British trials has been buried. In fact, almost 85% of the original 24,000 grams of plutonium remains on the surface.
In 24,000 years time, half of that plutonium will still be there, but in about 400 years from now, it will be difficult, if not impossible, to detect it.
On my last visit to Maralinga in September 1999, I was farewelled with, 'Well, see you in February for the handover'. I have heard many times that the site will be returned 'later in the year', or 'in the next few months', and seven years later I am still waiting for that event.
Will the Aborigines accept return of their land?
If they do, then for thousands of years, they will have to rely on the Federal government to honour any agreements they might enter, in full knowledge that only a few years ago, the government unilaterally broke their agreement to clean the site using the best available technology and then failed to do so.

The Kupa Piti Kungka Tjuta and the proposed radioactive waste repository in SA

In 1998, the Howard government announced its intention to build a radioactive waste repository near Woomera in South Australia. Leading the battle against the dump were the Kupa Piti Kungka Tjuta[179], a council of senior Aboriginal women from northern SA. Many of the Kungkas personally suffered the impacts of the British nuclear bomb tests at Maralinga and Emu in the 1950s.

The late Mrs. Eileen Kampakuta Brown, a member of the Kungka Tjuta, was awarded an Order of Australia on Australia Day in 2003 for her service to the community "through the preservation, revival and teaching of traditional Anangu (Aboriginal) culture and as an advocate for indigenous communities in Central Australia". On 5 March 2003, the Australian Senate passed a resolution noting "the hypocrisy of the Government in giving an award for services to the community to Mrs. Brown but taking no notice of her objection, and that of the Yankunytjatjara/Antikarinya community, to its decision to construct a national repository on this land."

The proposed repository was also opposed by Native Title claimant groups, namely the Kokatha and the Barngala.

The proposed repository was opposed by the Aboriginal and Torres Strait Islander Commission. (ATSIC). Acting Chair of ATSIC, Lionel Quartermaine, argued in a submission to ARPANSA in 2003:[180]

"The Nulla Wimila Kutju Regional Council is fully supportive of the Kupa Piti Kungka Tjuta ... who have been vocal in their opposition to the proposed [repository] siting. Many witnessed the effects on their people of the Atomic Tests conducted in their country in the 1950s. It is patently unfair that these should now once again face the prospect of being at risk of radiation exposure."

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[179] http://web.archive.org/web/20080718193150/http:/www.iratiwanti.org/home.php3
[180] Submission No.242 to ARPANSA inquiry into proposed national radioactive waste repository, http://web.archive.org/web/20040610143043/http://www.arpansa.gov.au/reposit/nrwr.htm
See also: Rebecca DiGirolamo, 16 Dec 2003, “ATSIC in fear of N-dump leakage”, The Australian, p.4.

A 14 April 2003 letter from the Federal Environment Department's Indigenous Advisory Committee stated:

"The Kupa Piti Kungka Tjuta, senior Aboriginal women of north SA, fundamentally oppose this nuclear waste dump which they see as the imposition of poison ground onto their traditional lands.
The Kokatha people, as registered native title claimants, oppose the nuclear waste dump and the intended acquisition and annulment of their native title rights and interests.
Throughout the EIS process under the EPBC Act, the Native Title claimants and other community members feel that there has not been adequate consultation. Traditional owners have also not been able to find out about the intended legal approach of the Commonwealth Government in carrying out key aspects of the proposed project."

All of these clear and public objections were ignored by the federal government.

Public relations

The proposed dump generated such controversy in SA that the federal government hired a public relations company.[181] Correspondence between the company and the government was released under Freedom of Information laws. In one exchange, a government official asks the PR company to remove sand-dunes from a photo to be used in a brochure.[182] The explanation provided by the government official was that: "Dunes are a sensitive area with respect to Aboriginal Heritage". The sand-dunes were removed from the photo, only for the government official to ask if the horizon could be straightened up as well.

False consultation and coercion

The Federal Government's approach to 'consultation' was spelt out in a document leaked in 2002.[183] The document states: "Tactics to reach Indigenous audiences will be informed by extensive consultations currently being undertaken ... with Indigenous groups." In other words, sham 'consultation' was used to fine-tune the government's promotion of the repository.

Aboriginal groups were coerced into signing agreements consenting to test drilling of short-listed sites for the proposed dump. The Federal Government made it clear that if consent for test drilling was not granted by Aboriginal groups, that drilling would take place anyway. A clear signal of the Government's intent to proceed regardless of Aboriginal support for or engagement in the process came on 30 April 1999, when the Federal Government issued a Section 9 notice under the Land Acquisition Act 1989 which gave the government legal powers to conduct work on land that it might acquire to site the dump.

Aboriginal groups were put in an invidious position:
- they could attempt to protect specific cultural sites by engaging with the Federal Government and signing agreements, at the risk of having that engagement being misrepresented or misunderstood as consent the dump per sé; or
- they could refuse to engage in the process, thereby having no say in the process whatsoever.

[181] http://pandora.nla.gov.au/pan/30410/20090218-0153/www.geocities.com/jimgreen3/wasteleak.html
[182] www.foe.org.au/anti-nuclear/issues/oz/nontdump/mw
[183] Department of Education, Science and Training, 2002, "Communication Strategy: Announcement of Low Level Radioactive Waste Site in SA".

It is important to note that given the current absence of any effective veto right over mining proposal on their lands – with the exception of some provisions on the Aboriginal Land Rights Act – this unsatisfactory and fundamentally unfair power imbalance remains the common Aboriginal experience today.

Aboriginal groups were between "a rock and a hard place" according to Stewart Motha from the Aboriginal Legal Rights Movement, which represented the Antakirinja, Barngarla, and Kokatha people in negotiations over the dump. Mr. Motha said:

"If Aboriginal groups do get involved in clearances [for test drilling] they face the possibility that the Government will point to that involvement as an indication of consent for the project. If they refuse to participate, who will protect Aboriginal heritage, dreaming and sacred sites?"

Parry Agius, manager of the Aboriginal Legal Rights Movement's Native Title Unit, said:
"The nuclear waste repository issue highlights the inadequacy of native title rights as they are currently constituted under the Native Title Act and is a showcase for the consequences of the 10 Point Plan. While native title purports to recognise Aboriginal peoples' particular relationship to the land, and the negotiations we are currently undertaking are aimed at protecting Aboriginal heritage, the commonwealth government may extinguish these rights by compulsory acquisition."

Dr. Roger Thomas, a Kokatha man, told an ARPANSA forum on 25 February 2004[184]:
"The Commonwealth sought from the native title claim group the opportunity to carry out site clearances. They presented to us, as a native title group, some 58 sites that they would like us to consider for the purpose of cultural significance clearance. Of the 58, there were seven sites that they saw as being the priority locations for where they had intentions to want to locate the waste repository. I would like it to be registered that, of the 58, the senior law men and women had difficulty and made it quite clear that there was no intent on their part to want to give any agreement to any of those sites. ... The point of concern and controversy for us is that we were advised − and we were told this by the various agencies involved − 'If you don't proceed with signing the agreement, the Federal Government will acquire it under the constitution legislation.' From our point of view, we not only had the shotgun at our head, we also were put in a situation where we were deemed powerless. If this is an example of the whitefella process and system that we've got to comply with as Indigenous Australians, then we attest that this whole process needs to be reviewed and looked at and we need to be given under the convention of the United Nations the appropriate rights as Indigenous first nation people. Our bottom line position is that we do not agree with any waste material of any level being dumped, located or deposited in any part of this country."

Aboriginal groups did reluctantly engage in surveys resulting in the signing of so-called Heritage Clearance Agreements. Heritage assessment surveys were conducted by three groups:
- Antakirinja, Barngala and Kokatha Native Title Claimant Groups;
- Andamooka Land Council Association; and
- Kuyani Association.

One risk was that those Heritage Clearance Agreements would be misrepresented by the Federal Government as amounting to Aboriginal consent to or even support for the dump per sé. That risk was in fact realised. Federal Government politicians and bureaucrats repeatedly made reference to the surveys and the resulting Agreements without noting that those Agreements in no way amount to consent to the

[184] 25 Feb 2004, ARPANSA inquiry public hearing, http://web.archive.org/web/20040610143043/http://www.arpansa.gov.au/reposit/nrwr.htm

dump. The following excerpt from Senate Hansard provides an example of this type of misrepresentation-by-omission (30 October, 2003, p.16813, question 2118):

> *Senator Allison (Australian Democrats) asked the Minister representing the Minister for Science, upon notice, on 18 September 2003:*
> *(e) have any Indigenous groups consented to the construction and operation of the repository at the site known as Site 40a; if so, which groups;*
> *(f) have any Indigenous groups stated that Site 40a has no particular Indigenous heritage values; if so, which groups;*
> *Senator Vanstone — The Minister for Science has provided the following answer to the honourable senator's question:*
> *(e) The site has been cleared for all works associated with the construction and operation of a national repository, with regard to Aboriginal heritage, by the Aboriginal groups with native title claims over the relative site as well as other groups with heritage interests in the region. These groups are the Antakirinja, Barngala and Kokotha Native Title Claimant Groups, the Andamooka Land Council Association and the Kuyani Association.*
> *(f) See answer to (e).*

There was no recognition in the above statement of Aboriginal opposition to the dump.

The same misrepresentation-by-omission occurred in the Environment Department's Environmental Assessment Report regarding the planned dump and in numerous other Federal Government statements.

Jeff Harris, an official with the federal government, told an ARPANSA forum that: "... those Aboriginal groups that have heritage interests in those lands we have consulted extensively with them, and each of the three sites that are going through environmental impact assessment has been inspected by these Aboriginal groups and have cleared for the construction and operation of the repository."[185]

The claim that the sites were "cleared for the construction and operation of the repository" was false.

The conflation between Heritage Clearance Agreements and consent for the construction and operation of a radioactive waste repository occurred repeatedly despite the fact that the Heritage Clearance Agreements specifically noted Aboriginal opposition. One such Agreement, between the Federal Government and the Antakarinja Native Title Group, the Barngarla Native Title Group and the Kokatha Native Title Claimant Group, dated May 12, 2000, included the following clauses:

> *E. The agreement to undertake Work Area Clearances is not to be deemed as consent, and the COMMONWEALTH do not under this Agreement seek such consent, by the Claimants to the establishment of a NRWR in the Central North Region of South Australia.*
> *I. The COMMONWEALTH acknowledges that there is "considerable opposition" to the NRWR within the Aboriginal community of the region, but notwithstanding that the Claimants have made a commitment that the heritage clearance and the contents of the Work Area Clearance Report will not be influenced by such opposition.*

The Federal government never publicly released those clauses of the Agreement.

Land seizure

[185] 17 December 2001, ARPANSA forum transcript, http://web.archive.org/web/20060826193328/http://www.arpansa.gov.au/rrrp_for.htm

In 2002, the Federal Government tried to buy-off Aboriginal opposition to the dump. Three Native Title claimant groups − the Kokatha, Kuyani and Barngala − were offered $90,000 to surrender their native title rights, but only on the condition that all three groups agreed. Two of the groups − the Kokatha and Barngala − refused, so the government's ploy failed.

Dr. Roger Thomas, a Kokatha man, told an ARPANSA forum on February 25, 2004[186]:
"The most disappointing aspect to the negotiations that the Commonwealth had with us, as Kokatha, is to try to buy our agreement. This was most insulting to us as Aboriginal people and particularly to our elders. For the sake of ensuring that I don't further create any embarrassment, I will not quote the figure, but let me tell you, our land is not for sale. Our Native Title rights are not for sale. We are talking about our culture, our lore and our dreaming. We are talking about our future generations we're protecting here. We do not have a "for sale" sign up and we never will."

According to *The Age*, the meetings took place at a Port Augusta motel in September 2002 and the Commonwealth delegation included representatives of the Department of the Attorney-General, the Department of Finance and the Department of Education and Science and Training.[187]

Dr. Thomas said: "The insult of it, it was just so insulting. I told the Commonwealth officers to stop being so disrespectful and rude to us by offering us $90,000 to pay out our country and our culture."[188] Andrew Starkey, another Kokatha man, said: "It was just shameful. They were wanting people to sign off their cultural heritage rights for a minuscule amount of money. We would not do that for any amount of money."[189]

In July 2003, the federal government used the Lands Acquisition Act 1989 to seize land for the dump. Native Title rights and interests were extinguished with the stroke of a pen.[190] This took place with no forewarning and no consultation with affected Aboriginal people.

Victory for the Kungkas

The Kupa Piti Kungka Tjuta continued to implore the federal government to 'get their ears out of their pockets', and after six long years the government did just that. In the lead-up to the 2004 federal election, with the repository issue deeply unpopular, and the Federal Court having rejected the government's use of urgency provisions in the Lands Acquisition Act, the Howard government decided to abandon the dump plan.

The Kungkas wrote in an open letter: "People said that you can't win against the Government. Just a few women. We just kept talking and telling them to get their ears out of their pockets and listen. We never said we were going to give up. Government has big money to buy their way out but we never gave up."[191]

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[186] 25 Feb 2004, ARPANSA forum, Adelaide, http://web.archive.org/web/20040610143043/http://www.arpansa.gov.au/reposit/nrwr.htm
[187] Penelope Debelle, "Anger over native title cash offer", The Age, May 17, 2003.
[188] Penelope Debelle, "Anger over native title cash offer", The Age, May 17, 2003.
[189] Penelope Debelle, "Anger over native title cash offer", The Age, May 17, 2003.
[190] Senator Nick Minchin, Minister for Finance and Administration, Media Release, July 7, 2003
[191] http://web.archive.org/web/20080720065153/http:/www.iratiwanti.org/iratiwanti.php3?page=news&id=244&start=0&year=2004

'Radioactive Ransom': Dumping on Muckaty Traditional Owners

Following the failure of the attempt to impose a national radioactive waste dump in SA, the Howard government announced in July 2005 that the Northern Territory would host a national radioactive waste dump, like it or not. This decision was in clear conflict with commitments given during the 2004 federal election.

A toxic trade-off was part of this story from the start. The nomination of the Muckaty site in the NT was made with the promise of a compensation package of a mixture of cash and increased service provision valued at $12 million. Traditional Owner Kylie Sambo objected to this 'radioactive ransom': "I think that is a very, very stupid idea for us to sell our land to get better education and scholarships. As an Australian we should be already entitled to that."

The Howard government passed legislation − the Commonwealth Radioactive Waste Management Act − overriding the Aboriginal Heritage Act and the Aboriginal Land Rights Act, and allowing the imposition of a nuclear dump with no Aboriginal consultation or consent.

The Labor Party voted against the Commonwealth Radioactive Waste Management Act, with Labor parliamentarians describing it as "extreme", "arrogant", "draconian", "sorry", "sordid", and "profoundly shameful". At its 2007 national conference, Labor voted unanimously to repeal the legislation. Yet after the 2007 election, the Labor government passed legislation − the National Radioactive Waste Management Act (NRWMA) [192] − which was almost as draconian and still permitted the imposition of a nuclear dump with no Aboriginal consultation or consent (to be precise, the nomination of a site was not invalidated by a failure to consult or secure consent).

ALP Minister Martin Ferguson drove the NRWMA through Parliament. He refused countless requests to meet with Traditional Owners opposed to the dump. Muckaty Traditional Owner Dianne Stokes said: "All along we have said we don't want this dump on our land but we have been ignored. Martin Ferguson has avoided us and ignored our letters but he knows very well how we feel. He has been arrogant and secretive and he thinks he has gotten away with his plan but in fact he has a big fight on his hands."

In February 2008, Labor Prime Minister Kevin Rudd highlighted the life-story of Lorna Fejo − a member of the stolen generation − in the National Apology in Parliament House.[193] At the same time, the Rudd government was stealing her land for a nuclear dump. Fejo said: "I'm very, very disappointed and downhearted about that [NRWMA legislation]. I'm really sad. The thing is − when are we going to have a fair go? Australia is supposed to be the land of the fair go. When are we going to have fair go? I've been stolen from my mother and now they're stealing my land off me."[194]

A small group of Traditional Owners supported the dump but a much larger group were opposed[195] and some initiated legal action[196] in the Federal Court challenging the nomination of the Muckaty site by the federal government and the Northern Land Council (NLC).

The Federal Court trial finally began in June 2014. After two weeks of evidence, the federal government acceded to the NLC's request not to proceed with the Muckaty nomination.[197] The announcement came

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[192] www.foe.org.au/anti-nuclear/issues/oz/nontdump/feb2010
[193] www.dfat.gov.au/indigenous/apology-to-stolen-generations/rudd_speech.html
[194] www.abc.net.au/radionational/programs/breakfast/2012-03-14/3887998
[195] www.beyondnuclearinitiative.com/
[196] www.abc.net.au/lateline/content/2012/s3452671.htm
[197] www.theguardian.com/commentisfree/2014/jun/19/muckaty-nuclear-dump-defeat-is-a-huge-victory-for-aboriginal-

just days before the NLC and government officials were due to take the stand to face cross-examination. Kylie Sambo said: "I believe [the NLC] didn't want to go through that humiliation of what they really done. But it's better now that they actually backed off. It's good for us."

As a result of their surrender, the NLC and the government did not have to face cross-examination in relation to numerous serious accusations[198] raised in the first two weeks of the trial − including claims that the NLC rewrote an anthropologists' report.[199]

Celebrating the successful battle against the NLC and the federal government, Marlene Nungarrayi Bennett said: "Today will go down in the history books of Indigenous Australia on par with the Wave Hill Walk-off, Mabo and Blue Mud Bay. We have shown the Commonwealth and the NLC that we will stand strong for this country. The NLC tried to divide and conquer us but they did not succeed."[200]

Lorna Fejo said: "I feel ecstatic. I feel free because it was a long struggle to protect my land."[201]

Dianne Stokes said: "We will be still talking about our story in the communities up north so no one else has to go through this. We want to let the whole world know that we stood up very strong. We want to thank the supporters around the world that stood behind us and made us feel strong."[202]

The uranium industry and Aboriginal people

It is also important for the Royal Commission to investigate the uranium industry's track record of stripping Aboriginal people of their land rights and heritage protections. One example concerns the 1982 South Australian Roxby Downs Indenture Act, which sets the legal framework for the operation of BHP Billiton's Olympic Dam uranium mine in SA. The Act was amended in 2011 but it retains exemptions from the SA Aboriginal Heritage Act. Traditional Owners were not even consulted during the period of the most recent ammendments. The SA government's spokesperson in Parliament said: "BHP were satisfied with the current arrangements and insisted on the continuation of these arrangements, and the government did not consult further than that."[203]

The following Parliamentary exchange (SA Legislative Council, 24 November 2011) provides more detail:[204]

> *The Hon. M. PARNELL: This is a most remarkable clause that deals with a most remarkable section of the current act. Section 9, which relates to the application of the Aboriginal Heritage Act to the Stuart Shelf and Olympic Dam areas. My main difficulty with this provision is that it imposes an outdated set of legal privileges to the company over Aboriginal heritage legislation. The reason I say 'remarkable' is that the regime here is that an old act (the old Aboriginal Heritage Act 1979) is the reference point, rather than the Aboriginal Heritage Act 1988, in the defined Stuart Shelf area and in the Olympic Dam area, which includes the special mining lease. I will go into some detail shortly as to why that is a remarkable legislative provision.*

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australia

[198] http://beyondnuclearinitiative.com/blog

[199] www.theage.com.au/federal-politics/political-news/indigenous-land-owners-accuse-lawyer-of-manipulating-nuclear-waste-storage-report-20140604-39jk8.html

[200] www.foe.org.au/muckaty-winnerz

[201] www.mauriceblackburn.com.au/about/media-centre/media-statements/2014/muckaty-station-nuclear-waste-dump-will-not-go-ahead-aboriginal-traditional-owners-succeed-in-legal-challenge/

[202] www.foe.org.au/muckaty-winnerz

[203] http://hansard.parliament.sa.gov.au/pages/loaddoc.aspx?e=2&eD=2011_11_24&c=26

[204] http://markparnell.org.au/speech.php?speech=1102

The first question I have relates to Stuart Shelf. When you look at the Stuart Shelf area map (map 2 on page 171 of the bill), and you also look at the description of the Stuart Shelf area (page 152 of the bill), we can see—but not that clearly—that it is a large part of South Australia. My understanding is that it was the original exploration area of interest to the original Roxby proponents. My question is: how big an area is that?

The Hon. G.E. GAGO: We do not know the—

The Hon. M. PARNELL: Well, I am guessing thousands of square kilometres, but if the minister can find out with any more certainty than that I would appreciate that.

The Hon. G.E. GAGO: We will do what we can.

The Hon. M. PARNELL: Thank you. As I understand it, the 1979 Aboriginal Heritage Act was passed by the parliament, but it was not proclaimed and was ultimately repealed, with the exception that it still applies in the case of the indenture in relation to these defined geographic areas I have been talking about; we do not know their size, but we know they are massive. When you go to the South Australian legislation website and you click on the link for acts of parliament, you do not even find the Aboriginal Heritage Act 1979; in fact, you have to click on the secret tab for ceased acts and acts of limited application. When you do that, you come up with the heading, 'Aboriginal Heritage Act 1979 (ceased)'. The notation says that the responsible minister is the Minister for Aboriginal Affairs and Reconciliation, and it states:

"This Act has never been brought into operation but has not been expressly repealed. Section 9 of the Roxby Downs (Indenture Ratification) Act 1982 applies this Act to certain operations. Apart from that, the Act has been effectively impliedly repealed by the Aboriginal Heritage Act 1988 and is, consequently, treated as a historical version."

My question of the minister (and I think it is the obvious question) is: why on earth is the Aboriginal heritage regime referred to in this legislation, a regime that was never passed into general South Australian law and has since been repealed, still the standard for this area and for this project?

The Hon. G.E. GAGO: I have been advised that that is what the agreement was at the time and that BHP currently are only willing to consider the continuation of the current arrangements.

The Hon. M. PARNELL: I thank the minister for her answer, but what a remarkable answer. A company has said to the people of South Australia, 'We don't like your Aboriginal heritage laws. The only laws that we are prepared to countenance even partially complying with are laws that have never been proclaimed and have never been applied anywhere else in the state of South Australia, and yet they applied under the 1982 indenture act.'

The follow-on question has to be that, okay, even if you accept—which I do not—that that was an appropriate thing to do in 1982, to apply an act that had never ever been proclaimed, why on earth did the government not take the opportunity in relation to the renegotiation of this indenture to at least insist that the current Aboriginal Heritage Act be the basis for the dealings between this company and Aboriginal people in South Australia, especially given that we are talking about a much bigger area, a new project and a new open-cut mine? Surely this was the opportunity to say to BHP Billiton, 'Sorry, but we are not going to give you the benefit of the 1979 act, you have to comply with the law of South Australia.' Why was that opportunity not taken?

The Hon. G.E. GAGO: I have been advised that BHP insisted that the current arrangements continue and they were not prepared to consider changes to that.

The Hon. M. PARNELL: I understand there have been negotiations in relation to an Indigenous land use agreement and other negotiations, but what negotiations did the government undertake with, for example, the Aboriginal Legal Rights Movement or other Aboriginal groups in relation to whether this old act should continue to apply or whether the government should insist on the more modern act applying? What consultation was there?

The Hon. G.E. GAGO: I have been advised that BHP were satisfied with the current arrangements and insisted on the continuation of these arrangements, and the government did not consult further than that.

The Hon. M. PARNELL: To take a slightly different tack, is the minister able to identify the key differences between the 1979 act and the 1988 act that made the older act so much more attractive to BHP Billiton in relation to Aboriginal heritage?
The Hon. G.E. GAGO: I have been advised that the 1979 act does not have a mandatory consultation provision equivalent to the 1988 act for determining sites and/or authorising damage, disturbance or interference. However, contemporary administrative law principles, particularly in relation to procedural fairness, necessitate the same or similar consultation.
The Hon. M. PARNELL: It seems that there is a lot less consultation involved. It just seems remarkable that the minister has talked about this good corporate citizen and hoping that their goodness will continue into the future, yet when it comes to being obliged to consult with Aboriginal communities they opt for the lowest standard that they can get.

Aboriginal land rights and heritage protections are repeatedly stripped away whenever they get in the way of uranium mining interests:

- The Olympic Dam mine is largely exempt from the SA Aboriginal Heritage Act.
- Sub-section 40(6) of the Commonwealth's Aboriginal Land Rights Act exempts the Ranger uranium mine in the NT from the Act and thus removed the right of veto that Mirarr Traditional Owners would otherwise have enjoyed.[205]
- NSW legislation exempts uranium mines from provisions of the NSW Aboriginal Land Rights Act.[206]
- The Western Australian government is in the process of gutting the WA Aboriginal Heritage Act 1972 at the behest of the mining industry, including the systematic deregistering of Aboriginal Heritage Sites.[207]

None of those exemptions is defensible. No attempt has ever been made to justify why the heritage protections and land rights legislation should be weakened at the behest of the uranium industry or why uranium mining should be exempted from land rights legislation.

Recommendation 15: The Royal Commission should investigate the pattern of Aboriginal heritage protections and land rights legislation being weakened or overriden to facilitate the uranium industry. The Royal Commission should recommend legislative change to rectify the situation, especially the introduction of a credible veto provision to help address the current systemic power imbalance that exists between mining companies and Aboriginal landowners.

Divide and rule tactics

Heathgate's activities at Beverley have been extremely divisive among Adnyamathanha Traditional Owners. Some Adnyamathanha Elders have formed an Elders Group as a separate forum from the Adnyamathanha Traditional Lands Association. Enice Marsh said:
"There have been many attempts over the past 10 years to try and bring greater accountability to what's happening in Native Title, and to stop the ongoing assault on our Yarta (country). Many of us have tried with very little resources, limited understanding of the legal system and environmental laws, and despite a mountain of bullying, lies and deceit from mining companies, lawyers, and self-inflated thugs in our own community who dare to call themselves 'leaders'."[208]

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[205] http://web.archive.org/web/20130425181741/www.mirarr.net/duress1.htm
[206] www.parliament.nsw.gov.au/prod/parlment/nswbills.nsf/131a07fa4b8a041cca256e610012de17/f82a7f63ed98b020ca2579a500209b70?OpenDocument
[207] http://blakandblack.com/2012/06/27/amendments-to-was-aboriginal-heritage-act-a-mining-industry-friendly-high-jacking/ Mia Pepper, 19 April 2015, 'Radioactive racism in the Wild West – WA takes aim at remote communities', http://thestringer.com.au/radioactive-racism-in-the-wild-west-wa-takes-aim-at-remote-communities-10123
[208] http://yurabila.wordpress.com/media-releases/

The company negotiated with a small number of Native Title claimants, but did not recognise the will of the community as a whole. This divide and rule strategy, coupled with the joint might of industry and government, resulted in inadequate and selective consultation with the Adnyamathanha people.

Adnyamathanha woman Jillian Marsh wrote in a submission to a 2002−03 Senate inquiry:[209]

Initial negotiation was misrepresentative, ill-informed, and designed to divide and disempower the Adnyamathanha community. ... The resulting meeting was held under appalling conditions. The company (Heathgate Resources) censored the entire meeting with the assistance of [a Liberal member of the SA Parliament] and the State Police. One Adnyamathanha man that stood up and asked for an independent facilitator from the floor to be elected was immediately escorted by two armed Police holding him on either side (by his arms) to the outside of the building.

The late Mr Artie Wilton, the last living Wilyaru man (Adnyamathanha full initiate), said in June 2000 that he was never consulted about the Beverley uranium mine and never agreed to the project.

Olympic Dam / Roxby Downs provides another example of divide and rule tactics being used by the uranium industry against Traditional Owners − including a notorious incident when WMC's divisive activities led to violence and death.[210] That incident concerned the laying of a water pipeline on the land of Arabunna Traditional Owners in the mid-1990s, when WMC Resources owned the mine. The dispute over the pipeline led to violence, terrorism, imprisonment, and the death of one person. Jan Whyte and Ila Marks summarised the controversy in 1996:[211]

"It appears that WMC has embarked on a course of side-stepping consultation with the Arabunna as the traditional custodians. It has also taken similar actions in regard to the Kokotha, the traditional custodians for the actual mine site. One method used by mining companies to side-step proper consultation processes is documented in North America and Canada as well as Australia. Mining companies incorporate small Aboriginal groups in areas under dispute and give them financial support. These groups are then regarded as the official representatives for that area and mining companies proceed to consult with them. Thus, it seems as if the companies are going through the correct legal processes whereas, in fact, they are ignoring parties who have legitimate interests."

1.10 Would a future expansion of exploration, extraction and milling activities create new environmental risks or increase existing risks? If so, are current strategies for managing those new risks sufficient? If not, in what specific respects? How would any current approach need to changed or adapted?

Introduction

Current strategies for environmental protection are inadequate. Problems include the failure of SA government departments to properly monitor uranium mines (see for example the Olympic Dam section below) and moves to curtail federal government involvement in mine approval processes.

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[209] Senate References and Legislation Committee, October 2003, 'Regulating the Ranger, Jabiluka, Beverley and Honeymoon uranium mines', www.aph.gov.au/Parliamentary_Business/Committees/Senate/Environment_and_Communications/Completed%20inquiries/2002-04/uranium/index

[210] ABC Background Briefing, 5 March 1995, 'Violence in Marree - WMC Interference', www.foe.org.au/anti-nuclear/issues/oz/u/roxby/1990s

[211] ABC Background Briefing, 5 March 1995, 'Violence in Marree - WMC Interference', www.foe.org.au/anti-nuclear/issues/oz/u/roxby/1990s

A 2003 report by the Senate References and Legislation Committee found "a pattern of under-performance and non-compliance" in the uranium mining industry.[212] It identified many gaps in knowledge and found an absence of reliable data on which to measure the extent of contamination from the uranium mining industry, and it concluded that changes were necessary "in order to protect the environment and its inhabitants from serious or irreversible damage". The committee concluded "that short-term considerations have been given greater weight than the potential for permanent damage to the environment".

The following comments focus on operating mines in SA (and ISL mines in care and maintenance).

Olympic Dam

Environmental spills at Olympic Dam[213] range from the trivial to the spectacular leak of around 5 million cubic metres of tailings liquid in the early to mid-1990s.[214]

Whistleblower revelations: tailings leaks: Photos taken by an Olympic Dam mine worker in December 2008 showed multiple leaks of radioactive tailings liquid from the so-called rock armoury of the so-called tailings retention system. The leaks were ongoing for a period of around six months. BHP Billiton's response was to threaten "disciplinary action" against any worker caught taking photos of the mine site. BHP Billiton claimed that the "allegations" related to a single incident when a small damp patch appeared on the wall of the tailings retention system. In fact, the photos clearly showed multiple leaks, and the leaks were ongoing for months.[215]

Recommendation 16: The Royal Commission should ascertain whether BHP Billiton still threatens "disciplinary action" against any worker caught taking photos of the mine site, and if such threats are consistent with world's best practice.

Recommendation 17: The Royal Commission should ask BHP Billiton why it claimed that "allegations" raised in the media in 2009 referred to a single incident involving a small damp patch on the wall of the tailings retention system, when in fact publicly-released photos clearly showed multiple leaks, and the leaks were ongoing for months.

Freedom of Information revelations − inadequate tailings management: Mining consultants Advanced Geomechanics noted in a 2004 report, obtained by *The Australian* under Freedom of Information laws, that radioactive slurry was deposited "partially off" a lined area of a storage pond, contributing to greater seepage and rising ground water levels; that there was no agreed, accurate formula to determine the rate of evaporation of tailings and how much leaks into the ground; that cells within a tailings pond covered an area more than three times greater than a key performance indicator recommended; and that "urgent remedial measures" were required.[216]

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[212] Senate References and Legislation Committee, October 2003, 'Regulating the Ranger, Jabiluka, Beverley and Honeymoon uranium mines', www.aph.gov.au/Parliamentary_Business/Committees/Senate/Environment_and_Communications/Completed%20inquiries/2002-04/uranium/index

[213] Some spills and other incidents from 2003 to 2014 are listed at: http://minerals.dmitre.sa.gov.au/mines__and__developing_projects/approved_mines/olympic_dam/olympic_dam_incident_summary_since_2003
Some spills and other incidents from 1987 to 2001 are listed at: www.foe.org.au/anti-nuclear/issues/oz/u/roxby/incidents

[214] www.foe.org.au/anti-nuclear/issues/oz/u/roxby/leak1994

[215] *The Monitor*, 1 April 2009, 'BHP Billiton opens up on tailings', http://web.archive.org/web/20090912230611/http://themonitor.com.au/editions/2009/APR01-09.pdf

[216] Michelle Wiese Bockmann, 10 March 2006, 'Waste fears at uranium mine', *The Australian*.

Recommendation 18: The Royal Commission should determine whether current tailings management practices are adequate at Olympic Dam and whether the FoI-based issues reported by *The Australian* newspaper in 2006 have been rectified. This is particularly important in the context of the tailings management implications of BHP's current move towards heap leach processing.

Indenture Act: The SA Roxby Downs Indenture Act overrides key South Australian legislation including the Environment Protection Act, the Water Resources Act and the Freedom of Information Act.[217]

There is nothing inherently objectionable with an indenture act for a major project, but the extent of the exemptions and overrides enjoyed by the Olympic Dam mine are indefensible and highly problematic.

An indication of the *realpolitik* and consistent prioritizing of corporate over community interest was provided by then SA Liberal Party industry spokesperson Martin Hamilton-Smith, who said in Parliament on 8 November 2011, in relation to the *Roxby Downs (Indenture Ratification) (Amendment Of Indenture) Amendment Bill 2011*, that "every word of the [indenture] agreement favours BHP, not South Australians."[218] Yet the Liberal Party did not oppose or try to improve the Labor government's Bill.

Recommendation 19: The Royal Commission should thoroughly investigate the Roxby Downs Indenture Act and recommend far-reaching legislative change to address the Act's multiple indefensible exemptions and overrides.

Bird Deaths: Stroboscopes and other methods are used to prevent birds drinking toxic liquid tailings, but large numbers of bird deaths are sometimes recorded − such as the recording of 100 bird deaths over a four day period.[219]

Recommendation 20: The Royal Commission should investigate bird deaths at Olympic Dam and ascertain if current measures to prevent bird deaths are adequate.

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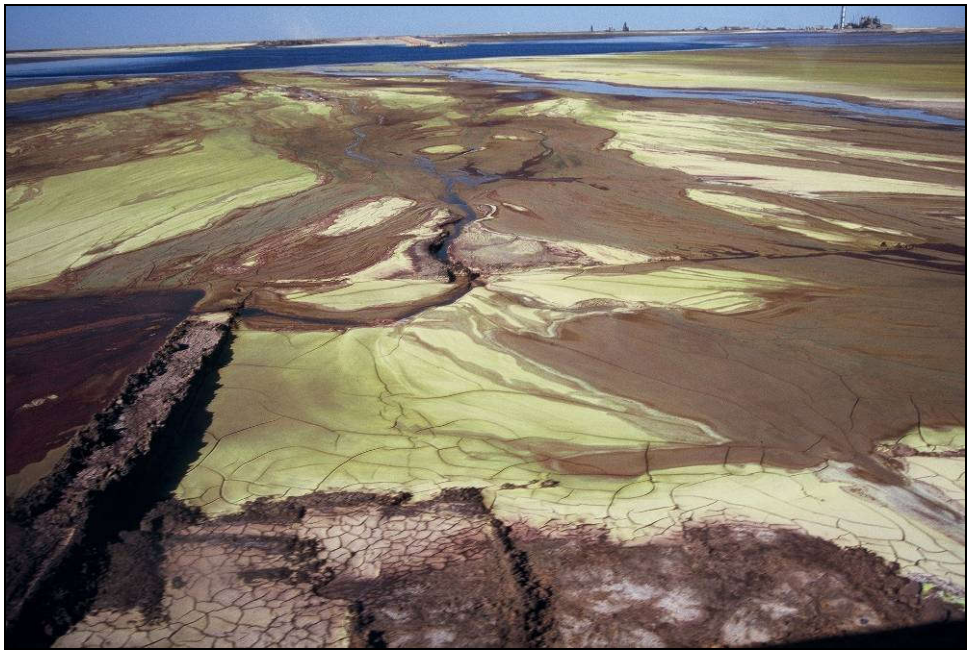
[217] Parliamentary discussions posted at: http://markparnell.org.au/speech.php?speech=1102
and http://markparnell.org.au/speech.php?speech=1103
Other information posted at: www.foe.org.au/anti-nuclear/issues/oz/u/roxby/indenture

[218] http://web.archive.org/web/20140308080015/http://martinhamilton-smith.com.au/Features/Speeches/tabid/86/articleType/ArticleView/articleId/3250/Roxby-Downs-Indenture-Ratification-Amendment-Of-Indenture-Amendment-Bill-2011.aspx

[219] ABC, 11 Jan 2005, 'WMC acknowledges tailings dangerous for birds', www.abc.net.au/news/2005-01-11/wmc-acknowledges-tailings-dangerous-for-birds/616658



Radioactive tailings waste at Olympic Dam, with the mine in the background.

Tailings and rehabilitation costs:

Tailings are stored above ground at Roxby Downs. The tailings dump currently amounts to well over 100 million tonnes and is growing by around 10 million tonnes annually. Serious questions over the long-term management of tailings waste remain unanswered including funding for long-term rehabilitation.

The Switkowski report stated: "Greater certainty in the long-term planning at Olympic Dam is desirable, coupled with guaranteed financial arrangements to cover site rehabilitation."[220] The Switkowski report further stated: "Best modern practice requires a whole-of-life mine plan including proposed plans for rehabilitation. A bank bond is normally required to cover the estimated costs of rehabilitation. Such plans are revised regularly to take into account changing conditions. However, the legislation under which Olympic Dam operates does not put in place an arrangement to guarantee that finance will be available to cover rehabilitation costs."

Recommendation 21: The Royal Commission should investigate whether arrangements to cover rehabilitation of the Olympic Dam site are adequate.

The Switkowski report stated: "Plans for final restoration of the Ranger mine are well established, based on a fully costed plan. Mandatory rehabilitation objectives include ecosystem viability, radiological safety, and landform stability. Costings are amended annually to update the guarantee by Energy Resources of Australia, which is held by the Australian Government."[221]

Less than a decade later, those statements have proven to be false. Energy Resources of Australia does not have sufficient resources for rehabilitation and is reliant on its parent company Rio Tinto to meet the shortfall. The funding shortfall for the rehabilitation is believed to be between $200 million and $500 million.[222]

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[220] Switkowski Review, 2006, 'Uranium Mining, Processing and Nuclear Energy Review', http://pandora.nla.gov.au/tep/66043
[221] Switkowski Review, 2006, 'Uranium Mining, Processing and Nuclear Energy Review', http://pandora.nla.gov.au/tep/66043
[222] Peter Ker, 15 June 2001, 'ERA shares in death spiral as prospects slashed', www.theage.com.au/business/mining-and-resources/era-shares-in-death-spiral-as-prospects-slashed-20150615-gho6jg.html

Water consumption and the Mound Springs: The impact of Olympic Dam's water consumption on the Mound Springs, fed by the Great Artesian Basin, has long been controversial[223] and the Royal Commission is well placed to shed light on this controversy.

Recommendation 22: The Royal Commission should investigate the impact of Olympic Dam's water consumption on the Mound Springs, and recommend appropriate measures to prevent further adverse effects on the Mound Springs.

No-uranium option for Olympic Dam: A 2010 report by Dr Gavin Mudd from Monash University assesses the viability of copper, gold and silver mining at Olympic Dam without uranium processing and export.[224] The report was prepared when an open-pit mega-expansion was still being proposed but aspects of the analysis are still relevant. Dr Mudd's report concludes: "Overall, not recovering the uranium is not only technically feasible but could also help reduce energy and water inputs as well as pollution outputs for the next expansion, as well as helping to address the various environmental, public health, environmental and security hazards associated with uranium and the nuclear chain in general."

BHP Billiton has been reluctant to even examine the no-uranium option; the company prefers to sell uranium to nuclear weapons states, dictatorships etc. The SA government did not require BHP Billiton to assess a no-uranium option for the EIA for the proposed (and later abandoned) mega-expansion.

Recommendation 23: The Royal Commission should investigate the environmental, economic and other impacts of mining copper, gold and silver but not uranium at Olympic Dam.

Claims of 'world's best practice' vs reality of failing to meet Australian best practice

In July 2011, SA Greens MLC Mark Parnell moved a motion calling on the SA government to ensure 'world's best practice' in waste management for the proposed Olympic Dam expansion.[225] The government ought to have supported the motion, not least because then Premier Mike Rann had promised "world's best practice in terms of the environment" at Olympic Dam. Yet the government did not support the motion.

Mr Parnell's speech[226] to Parliament is copied here as it neatly illustrates the *realpolitik* of political double-speak and inadequate standards at Olympic Dam which clearly do not meet Australian best practice standards let alone worldwide best practice.

> *Legislative Council*
> *GREENS MOTION: Olympic Dam 'World's Best Practice' Waste Management*
> *July 6, 2011*

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[223] Mudd, G M, 2000, Mound Springs of the Great Artesian Basin in South Australia: A Case Study From Olympic Dam. Environmental Geology, 39 (5), pp 463-476. www.springerlink.com/link.asp?id=100512, posted at: www.foe.org.au/sites/default/files/Mound%20Springs%20Mudd%201998.pdf
Mudd, G M, 1998, The Long Term Sustainability of Mound Springs In South Australia: Implications For Olympic Dam. Proc. "Uranium Mining & Hydrogeology II Conference", Freiberg, Germany, September 15-17 1998, pp 575-584. http://users.monash.edu.au/~gmudd/files/1998-UMH-2-ODam-v-MoundSprings.pdf
Daniel Keane, "The sustainability of use of groundwater from the Great Artesian Basin, with particular reference to the south-western edge of the basin and impact on the mound springs", www.foe.org.au/sites/default/files/Keane%20Mound%20Springs%2097.pdf

[224] Gavin M. Mudd, December 2010, 'The Olympic Dam Mega-Expansion Without Uranium Recovery', www.foe.org.au/sites/default/files/Mudd-non-U-option-ODM.pdf

[225] www.markparnell.org.au/speech.php?speech=1056

[226] www.markparnell.org.au/speech.php?speech=1056

On the 6th of July, Mark moved a motion calling on the government to ensure 'world's best practice' in waste management for the proposed Olympic Dam Expansion.
The Hon. M. PARNELL: I move:
That this council calls on the state government to ensure that all waste management practices for the proposed Olympic Dam Expansion, including the management of surplus ore and tailings, meet or exceed world's best practice.
This council will shortly face one of its most important decisions as it considers the granting of a new indenture for the Olympic Dam mega expansion. We need to get this right to ensure that our state is not left with a toxic legacy.
This motion today is very simple, and many would say that it is a little bit lacking in ambition. Surely the people of South Australia can expect in this day and age that any new project in a wealthy first-world nation such as Australia—especially a project as large and important as this one—would be subject to the most stringent environmental conditions. I think it is eminently reasonable as an expectation, therefore, the people of South Australia should fully expect all their representatives in this parliament—including those from both Liberal and Labor—to support this motion.
Certainly BHP Billiton believes that it should be subject to the world's best practice standard because, in a forward to the supplementary EIS released in May, Dean Della Valle, the President of the Uranium Customer Sector Group of BHP Billiton wrote:
"BHP Billiton, as the world's largest mining company, is well placed to develop a project of this importance and magnitude while ensuring best practice in health, safety, environmental management and community engagement."
In February this year, BHP Billiton chairman Jac Nasser wrote in a letter to the Australian Conservation Foundation:
"The Olympic Dam project uses world's best practice and many areas of the project will establish world's leading practice and set a new benchmark for others to follow."
So does the federal ALP, stating in its national platform in August 2009:
"Labor will ensure that Australian uranium mining, milling and rehabilitation is based on world's best practice standards."
Certainly the Premier of our own state thinks so as well, the Hon. Mr Rann announcing in May 2009, when the original EIS was released:
"It [the expansion project] has got massive benefits for South Australia, but I will insist that world's best practice in terms of the environment is complied with."
I do not need to remind Liberal members of this chamber that a desire for the most stringent environmental conditions is a genuine concern for them as well. The member for MacKillop in another place said on ABC Radio in May this year:
"...the Liberal Party's always been very supportive of BHP Billiton and this particular project. It is an incredibly important project for the state...but I've always said—and Isobel Redmond has always said—that BHP has to meet the most stringent environmental standards, and I think the government have said the same thing. I don't think any of us are going to sit back and allow BHP to be environmental vandals, and I don't think that BHP expect to behave in that way either."
With all this seemingly genuine acceptance from Labor, Liberal and the company itself, for world's best practice environmental management at Olympic Dam, I am surprised and disappointed that we have come so far in this process with basic elements of the waste management practice proposed for the Olympic Dam expansion project clearly not, by any definition, meeting world's best practice.
To give one very simple example, the company's plans for the management of tailings, waste and rehabilitation at Olympic Dam do not comply with existing commonwealth requirements and standards for the management of radioactive tailings waste at the Ranger uranium open pit mine in the Northern Territory. The reason the Ranger mine is an appropriate comparison is that it is the only other open pit uranium mine currently operating in Australia; therefore, its conditions are current best practice standards in Australia.

For the Ranger mine, the commonwealth requires that the environment must be protected from the hazards and risks of radioactive tailings waste for at least 10,000 years. Conditions and regulatory standards have been set for the existing Ranger uranium mine that all tailings must be disposed of into the pit:

"...in such a way to ensure that the tailings are physically isolated from the environment for at least 10,000 years—"

And to ensure—

"...any contaminants arising from the tailings will not result in any detrimental environmental impact for at least 10,000 years."

So, we have one uranium project in the Northern Territory with these worlds best practice conditions and, yet, for another uranium mine here in South Australia, the company behind the project does not intend to go anywhere near meeting this standard.

I can give another example that is even closer to home. The Terramin Angus mine near Strathalbyn was required to double line the whole of its tailings pond. As I will explain to members shortly, the Olympic Dam tailings ponds are not even single lined. In fact, they are not even half lined; in fact just 4 per cent of the tailings ponds at Olympic Dam will be lined. So, why does a wealthy company like BHP Billiton expect lower standards and less stringent requirements for the Olympic Dam mine expansion than current industry standards for a mine at Strathalbyn? How can anyone—the Premier, the opposition or BHP Billiton—themselves claim that the waste management at Olympic Dam goes anywhere near being world's best practice when it is not even South Australian best practice, let alone Australian best practice?

For the benefit of members who have not had a chance to read the 20,000 or so pages of the original environment impact statement or the supplementary EIS released by BHP Billiton, I will quickly outline what are the proposed waste management practices for the Olympic Dam mega expansion. Before I do that, I need to give members a quick refresher on why effective management of ore and tailings is so important. I will not concentrate on the radioactivity because, as members all know, the recent meltdown at Fukushima in Japan has already provided us with a terrible example of what dangers radioactive materials pose when they are not appropriately handled.

Instead I will focus on another aspect which makes these materials so dangerous, and that is acidity. On the whole, metals are not found in pure seams but as small mineral grains dispersed within a host rock. There are many types of these minerals, collectively known as sulphide minerals. A basic sulphide mineral has a metal attached to sulphur, like copper sulphide or iron sulphide. Sulphide minerals present an enormous problem for mining worldwide because of the way they weather. When these minerals are exposed to air and water, they dissolve to form acid. Typically, rainwater falls on to the host rock and, as it drains over, the sulphide grains oxidise into free particles and sulphuric acid. This acid is good at drawing out and holding other free metals in solution.

What happens next depends on how much is exposed. If the amount is small, dissolution is caused by a relatively slow chemical oxidisation. Because it happens slowly, acid neutralises quickly and metals drop out of solution as secondary minerals. These secondary minerals can be protective as they can be quite insoluble and form a cover against water. However, if the amount is large, such as the case at Olympic Dam, a general acidity build-up creates perfect conditions for extreme acid-loving bacteria that feed off the ore body, acting as a catalyst for the oxidation reaction, dramatically speeding it up and causing a snowball effect.

This biological oxidation is extremely difficult to treat, and it has a very large impact on the environment. Large scale oxidisation is an enormous problem for mining because the acid solution, known as acid drainage, is often very strong, with a pH typically lying between 1 and 3. The strong acidity draws out and carries metals far in excess of any kind of environmental guideline and holds them in a form which readily transfers it into living tissue. It generally contains heavy metals such as lead, arsenic, mercury or cadmium.

The exact composition of acid drainage reflects that of the ore body, and in some of the worst cases will include uranium. There are two particular areas of concern at Olympic Dam: the radioactive tailings and the management of the overburden and the surplus ore. First, the radioactive tailings: tailings are the most potent waste component of a mine. They are waste product of metal extraction: high grade, finely crushed ore particles found at the bottom of a tailings dam, mixed with fluid to create a toxic sludge.

The current 400 hectares of low-lying tailings at Olympic Dam will be increased to 4,000 hectares and will reach a height of 65 metres. That is an equivalent area to about 2,000 football fields. For each of the nine new dams proposed, the central decant pond and a little extra will be lined with 1.5 millimetre HDPE plastic. The plastic will only cover 16 hectares of each dam, a maximum lining of around 4 per cent of the proposed 44 square kilometre tailings facility. As a consequence, the EIS makes it clear that BHP Billiton expects the tailings dam to leak—and leak it most certainly will.

According to the Australian Conservation Foundation, up to 8.2 million litres of liquid radioactive waste each day through the first 10 years of operations will leak, and some 3.2 million litres per day through to the year 2050. This will cause a mound of seepage into the groundwater below the so-called storage facility that would affect groundwater levels for up to six kilometres. BHP Billiton estimates that around 1.5 billion litres of toxic tailings will seep out every single year. It will take between 800 and 10,000 years before acidity would be depleted from these tailings.

Upon completion of works, the tailings storage facility will have a radioactivity level in the order of 10,000 to 20,000 becquerels per litre, which will almost certainly make it the largest and most toxic radioactive tailings dam in the world. The leachate will be horrendous, containing radioactive materials and other toxic substances in a pool of sulphuric acid. The expectation that this toxic liquid will leak for thousands of years is simply not acceptable, and it is certainly not the current commonwealth statutory regulatory requirement for the Ranger mine.

The current tailings dam is already leaking and is quite likely to have contaminated the underlying aquifer. The scale of the proposed tailings storage dam, as part of the Olympic Dam expansion, will dramatically increase the size and rate of this contamination. To get anywhere near world's best practice management, BHP Billiton must be required to prove that they will prevent further contamination of local groundwater and that they will line a sufficiently high percentage of the tailings area to achieve a standard to effectively prevent leakage.

BHP Billiton should also have to reveal the cost of investment in these basic environmental protection measures—for example, to effectively line the tailings piles to prevent leakage and to protect local groundwater—that they are seeking to avoid in their plans in the supplementary EIS by only lining some 4 per cent of the tailings storage facility.

The company has deep pockets and should be willing to pay to match their commitment to not just world's best practice but, according to their chairman, world's leading practice. The people of South Australia have a right to see the investment relationship between increasing the area of lining and reduced leakage rates.

In the original EIS submission, BHP Billiton offered (but did not commit) to a number of different options to manage or cap the tailings storage facility when completed. It gave sound (but expensive) measures along with ineffectual (but cheap) alternatives. Ominously, the supplementary EIS suggests BHP Billiton will take a step backwards from even the cheapest and least effective option outlined in the original EIS and use a non-vegetated limestone cap. Once again, this is far below world's best practice.

The second major area of concern is the rock waste heap, or rock storage facility, and there are actually two parts to this. First, there is the overburden, the ore that will take about five years to dig up and stockpile and, secondly, the class A material, which is essentially low grade ore that is uneconomic to process at the moment but the company may think about processing it in the future. This class A material will be stored in the so-called low grade ore stockpile, or LGS. The environmental effect of the rock waste heap is not adequately described in either the EIS or the

supplementary EIS. This is a clear flaw in those statements, as the waste heap is likely to be second only to the tailings dam in its potential to cause major ground level pollution. Inexplicably, there appears to be no protection from erosion and no vegetation cover as part of site rehabilitation. The class A material is going to be stored on the south-west tip of the waste heap over the existing airport. It will not be covered for at least 40 years, in case it becomes economically viable to process. This huge quantity of class A material will generate acidic leachate containing heavy metals, which will quite likely include toxic uranium, copper and other metals. The proximity to the Roxby Downs township of class A material is deeply concerning and presents a genuine and unacceptable risk to local vegetation, flora and fauna and the nearby residents of Roxby Downs.

The unsubstantiated claim that it is not practical to rehabilitate in the desert is not backed by recent Australian and overseas projects. BHP Billiton must be required to fully rehabilitate all its waste rock dumps. Rehabilitation is a massive cost, and it should not be left to taxpayers. As a comparison, members should consider the considerable federal government financial liability as a result of inadequate rehabilitation at Rum Jungle mine in the Northern Territory for a project that was less than one-hundredth the size of Olympic Dam.

Without effective rehabilitation and appropriate management of the tailings and waste rock piles, BHP Billiton is effectively passing onto the government of South Australia the responsibility for the mining legacy at Olympic Dam—a legacy the commonwealth government recognises will last for at least 10,000 years.

In the only equivalent uranium open pit mine project in Australia, the Ranger uranium mine in the Northern Territory, the commonwealth has insisted that this responsibility remains with the company. BHP Billiton's risk reduction for its legacy, as described in the EIS and the supplementary EIS, is almost non-existent. For all intents and purposes, that land will never again support animal and plant life, and, as such will be exposed to the full extent of weathering. The best practice waste principle of either 'fully wet' or 'fully dry' management to minimise acid seepage is ignored by BHP Billiton as a cost-cutting measure. Surely we have learnt something from our own recent history. Let us look at a previous BHP project, the Brukunga mine near Mount Barker, which ceased operation in the 1970s. The Brukunga mine made the company about $10 million in today's money.

The state government sold the indemnity to BHP Billiton for $75,000, which is about $750,000 in today's money, yet the cost of remediating this site is of the order of $50 million for major earthworks (such as the tailings dam and waste heap) and around $600,000 annually in water collection and treatment, and this will be an annual cost for the taxpayers of South Australia for the next 200 years unless more comprehensive rehabilitation is carried out.

In terms of size, the Brukunga site has an eight megatonne waste heap. Olympic Dam will have a 242 megatonne waste heap, which is 30 times as large. The cost of rehabilitation is already five times the value of the ore that was extracted, with an ongoing liability for years and years and years. So, what would genuine world's best practice tailings and rock waste management actually look like?

The Australian Conservation Foundation believes that the Rann state government should require BHP Billiton to do the following three things: first, to prevent leakage of liquid radioactive waste in mine operations from the proposed tailings storage facility, including requiring BHP Billiton to fully line the area of this facility; secondly, to dispose of radioactive tailings into the pit to ensure isolation of the tailings from the environment and to ensure no detrimental environmental impacts for at least the same minimum 10,000 years as the regulatory standard that is required by the commonwealth for the radioactive tailings and open pit mine operations and rehabilitation of the Ranger mine in the Northern Territory; and, thirdly, to provide a costed rehabilitation plan for the proposed open pit at Olympic Dam, including the extent required for the disposal and isolation of tailings into the void of the proposed open pit with backfill or partial backfill with low-grade ore and waste rock, and to provide a commensurate rehabilitation bond from BHP Billiton.

I find it quite abhorrent that, in the 21st century, we are prepared to allow a private company to come into our state, make a huge toxic mess and then not properly clean up after itself, leaving the risk and the financial legacy for our children to manage. The Premier, the mining minister and the company are very happy to talk about world's best practice environmental management at Olympic Dam, but that is not what has been proposed so far by BHP Billiton for the Olympic Dam expansion—far from it; in fact, it is not even South Australian best practice. So I will be very interested to see if the government supports this motion.
If the Labor members opposite do vote in favour, they will be keeping faith with the public commitment made by Premier Rann in May 2009 when the original EIS was released. For the benefit of members I repeat his words: 'I will insist that world's best practice in terms of environment is complied with.'
A vote in favour of this motion is also an indication that the government believes that the management of the tailings and waste rock at Olympic Dam, as described by BHP Billiton in their EIS and supplementary EIS, is simply not adequate. It will mean that the Rann government believes BHP Billiton should be subject to the current minimum Australian regulatory standard: the requirement to effectively isolate their hazardous waste for the 10,000 years that the commonwealth believes those wastes pose a risk to the community.
The people of South Australia are getting a little bit sick of politicians who promise one thing and deliver another. This motion will test whether the Premier was genuine in his previous public commitments on the environmental impacts of this project. Finally, I will give notice to members now that as we are approaching the winter break, an expected end to this session, I will be bringing this motion to a vote on the next Wednesday of sitting, 27 July.

Recommendation 24: We note the long standing recognition of the threats posed by uranium mine tailings, including a Senate finding that viewed "tailings management as amongst the most serious challenges facing uranium miners and, indeed, the entire nuclear energy industry".[227] The Royal Commission should recommend that BHP Billiton should be required to meet both Australian best practice standards and world best practice standards in relation to tailings management.

In-situ leach uranium mines

Beverley, Beverley North, Beverley Four Mile and Honeymoon are acid in-situ leach (ISL) mines (only Four Mile is operating, the other three are in care and maintenance).

ISL involves pumping acid into an aquifer. This dissolves the uranium ore and other heavy metals and the solution is then pumped back to the surface for processing. The small amount of uranium is separated at the surface. The remaining liquid radioactive waste − containing radioactive particles, heavy metals and acid − is then simply dumped in groundwater. From being inert and immobile in the ore body, the radionuclides and heavy metals are now bioavailable and mobile in the aquifer.

A 2004 CSIRO report stated:
"As stated in the Beverley Assessment Report, the bleed solutions, waste solutions from uranium recovery, plant washdown waters and bleed streams from the reverse osmosis plants are collected prior to disposal into the Namba aquifer via disposal wells. These liquid wastes are combined and concentrated in holding/evaporation ponds, with excess injected into selected locations within the mined aquifer. The injected liquid is acidic (pH 1.8 to 2.8) and contains heavy metals and radionuclides originating from the orebody."[228]

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[227] Senate Select Committee on Uranium Mining and Milling, May 1997, p.63.
[228] Taylor, G.; Farrington, V.; Woods, P.; Ring, R.; Molloy, R. (2004): 'Review of Environmental Impacts of the Acid In-Situ Leach Uranium Mining Process', CSIRO Land and Water Client Report.

Heathgate has no plans to clean up the aquifer as it says the pollution will 'attenuate' − that the aquifer will return to its pre-mining state over time. This claim has been queried by the scientific community as being speculative with no firm science behind it.

In relation to the Beverley mine, Dr. Gavin Mudd, a hydrogeologist based at Monash University, states:[229]
"The critical data which could answer scientific questions concerning contaminant mobility in groundwater has never been released by General Atomics. This is especially important since GA [General Atomics] no longer maintain the mine is 'isolated' from surrounding groundwater, with desires to expand the mine raising legitimate concerns over the groundwater contamination legacy left at Beverley."

Dr Mudd states[230]:
Although ISL is presented in simplified diagrams by the nuclear industry, the reality is that geological systems are inherently complex and not predictable. ...
The chemicals can have potentially serious environmental impacts and cause long-term changes to ground water quality. ...
The use of acidic solutions mobilises high levels of heavy metals, such as cadmium, strontium, lead and chromium. Alkaline solutions tend to mobilise only a few heavy metals such as selenium and molybdenum. The ability to restore the ground water to its pre-mining quality is, arguably, easier at sites that have used alkaline solution chemistry.
A review of the available literature on ISL mines across the world can easily counter the myths promulgated about ISL uranium mining. Whether one examines the USA, Germany, Russia and associated states, Bulgaria, the Czech Republic, Australia or new ISL projects across Asia, the truth remains the same – the ISL technique merely treats ground water as a sacrifice zone and the problem remains "out of sight, out of mind".
ISL uranium mining is not controllable, is inherently unsafe and is unlikely to meet "strict environmental controls". It is not an environmentally benign method of uranium mining.
The use of sulphuric acid solutions at ISL mines across Eastern Europe, as well as a callous disregard for sensible environmental management, has led to many seriously contaminated sites.
Perhaps the most severe example is Straz pod Ralskem in the Czech Republic, where up to 200 billion litres of ground water is contaminated. Restoration of the site is expected to take several decades or even centuries.
Solution escapes and difficult restorations have been documented at ISL sites in Texas and Wyoming. Australia has encountered the same difficulties, especially at the controversial Honeymoon deposit in South Australia during pilot studies in the early 1980s and at Manyingee in Western Australia until 1985.
The Honeymoon pilot project used sulphuric acid in conjunction with ferric sulphate as the oxidising agent. The wells and aquifer experienced significant blockages due to the minerals jarosite and gypsum precipitating, lowering the efficiency of the leaching process and leading to increased excursions. The

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[229] www.foe.org.au/anti-nuclear/issues/oz/u/isl/articles
Several papers on ISL mining by Dr Mudd are posted at: http://users.monash.edu.au/~gmudd/publications.html
See for example:
Mudd, G M, 1998, An Environmental Critique of In Situ Leach Mining: The Case Against Uranium Solution Mining. Research Report for Friends of the Earth (Fitzroy) with The Australian Conservation Foundation, July 1998, 154p, http://users.monash.edu.au/~gmudd/files/1998-07-InSituLeach-UMining.pdf
Mudd, G M, 2001, Critical Review of Acidic In-Situ Leach Uranium Mining : 2 Soviet Block and Asia. Environmental Geology, 41 (3-4), pp 404-416, www.springerlink.com/link.asp?id=100512
Mudd, G M, 2001, Critical Review of Acidic In-Situ Leach Uranium Mining : 1 USA and Australia. Environmental Geology, 41 (3-4), pp 390-403, www.springerlink.com/link.asp?id=100512
[230] www.foe.org.au/anti-nuclear/issues/oz/u/isl/articles

aquifers in the vicinity of Honeymoon are known to be connected to aquifers used by local pastoralists to water stock.

The volume of liquid waste is significant as discussed in the 7 January 2009 *Beverley Four Mile Project Public Environment Report and Mining Lease Proposal* document[231]:
"With the inclusion of maximised recycling of water, approximately 2.5 L/s (averaged over a year) of liquid waste will be generated once the Beverley extraction circuits are decommissioned. This will be disposed of at Beverley ML 6321 in the hydraulically isolated formerly mined Beverley Sands aquifers in the North, Central and South wellfields.
"It is noted that initially the Beverley Four Mile resin elution circuit and Beverley ML 6321 capture and elution circuits will operate in parallel. During this time the combined volume of liquid waste will remain within an annualised average rate of 5 L/s.
"At the indicated rate there is enough disposal volume in those three wellfields to accommodate up to 16 years of liquid waste. Additional volume exists in Beverley North East, East and Deep South wellfields. Any extension of liquid waste disposal in these areas would be subject to a successful application to the regulatory authorities using the Beverley Mine Procedure for Management of Liquid Waste Disposal (Appendix C of the MARP, Heathgate 2008c) or its approved successor.

The 2003 Senate References and Legislation Committee report stated:
"The Committee is concerned that the ISL process, which is still in its experimental state and introduced in the face of considerable public opposition, was permitted prior to conclusive evidence being available on its safety and environmental impacts. "The Committee recommends that, owing to the experimental nature and the level of public opposition, the ISL mining technique should not be permitted until more conclusive evidence can be presented on its safety and environmental impacts. Failing that, the Committee recommends that at the very least, mines utilising the ISL technique should be subject to strict regulation, including prohibition of discharge of radioactive liquid mine waste to groundwater, and ongoing, regular independent monitoring to ensure environmental impacts are minimised."

Yet ISL mining continues (albeit the case that only Four Mile is operating, while Beverley, Beverley North and Honeymoon are in care and maintenance), as does the discharge of toxic liquid waste into groundwater.

The 2004 CSIRO report endorsed the dumping of liquid waste in ground-water yet the information and arguments it used in support of that conclusion were tenuous. The CSIRO report notes that attenuation is "not yet proven" and the timeframe of "several years to decades" could hardly be more vague.

The 2004 CSIRO report states in its Executive Summary:
"The use of acid rather than alkaline leaching and disposal of liquid wastes by re-injection into the aquifer is contentious. Available data indicate that both the leach solution and liquid waste have greater concentrations of soluble ions than does the pre-mining groundwater. However as this groundwater has no apparent beneficial use other than by the mining industry, this method of disposal is preferable to surface disposal. Although not yet proven, it is widely believed and accepted that natural attenuation will result in the contaminated water chemistry returning to pre-mining conditions within a timeframe of over several years to decades."

Elsewhere the 2004 CSIRO report notes uncertainties associated with attenuation:
"The EIA for Beverley and Honeymoon suggest that natural attenuation will occur, however, exact timeframes are not given. The issue of predicting attenuation is made more complex by not fully

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[231] URS, 7 Jan 2009, prepared for Heathgate Resources, 'Beverley Four Mile Project Public Environment Report and Mining Lease Proposal'.

understanding the microbiological or the mineralogy of the surrounding ore bodies, before and after mining, and how these natural conditions will react with the altered water quality introduced by the injection of leachate, and re-injection of wastewaters. Following general practice, geochemical modelling was undertaken with a series of assumptions where data were not available. Although these assumptions are considered reasonable by the review team, some technical experts have a differing opinion. In any case the results must be considered approximate.
The monitoring results from Beverley are limited by the short duration of mining and operation, and there are currently no completely mined-out areas for which the water chemistry can be followed after mining to verify the extent of the expected natural attenuation. However, pH results for an area that was trial-mined in 1998 and then left until full-scale mining of the same area was due are shown in Figure 13.
Note that whilst other data are available for these wells there are not consistent trends in other analytes. There has been little recovery of groundwater chemistry towards background in the test-production wells other than a favourable change for pH. There are presently no equivalent monitoring data for the northern area, which is presently being mined."

Even if full attenuation does occur over time, it is unlikely to occur in the timeframe of post-mine-closure monitoring proposed by the mining proponent. The 7 January 2009 *Beverley Four Mile Project Public Environment Report and Mining Lease Proposal* document states:
"Heathgate proposes an initial period of five years from the conclusion of commercial operations to complete the decommissioning of facilities. A monitoring and maintenance program is proposed to run for a further two years, for a total of seven years from the final conclusion of mining activities. The total monitoring period will be reviewed with the regulatory authorities and may be extended.
Facilities will therefore be fully decommissioned within seven years from the conclusion of the commercial operation. This period includes a post-completion monitoring period for vegetation maintenance, groundwater sampling, drainage repairs and other activities to ensure the long-term permanent rehabilitation of the site."

The 2004 CSIRO report states:
"Natural attenuation is preferred to adjusting the chemistry of the wastewater prior to re-injection as the latter would result in the need for additional chemicals on-site, generation of contaminated neutralisation sludges which would have to be disposed of, risk of potential clogging of pore spaces in the aquifer and associated higher costs."

Those are not insurmountable problems. Moreover there are alternatives to adjusting the chemistry of waste-water then reinjecting it into the aquifer, such as evaporation followed by management of solid wastes. As the CSIRO report notes:

> *10.6 Alternatives to Liquid Waste Re-Injection*
> *Suggestions made during the community consultation process included not re-injecting the liquid wastes into the aquifer, and neutralisation of waste before re-injection.*
> *Not re-injecting the waste into the aquifer would require either sophisticated water treatment and/or the installation of much larger evaporation ponds. Both would generate solid wastes to be disposed of in a solid waste repository. When the wastes dried out they would become a possible dust source, which could increase the potential radiation exposure of workers, in particular in relation to dust inhalation, but also from radon inhalation and gamma exposure. Environmental radiation levels at the surface would also increase. These are presently negligible issues associated with the existing ISL practices.*
> *Neutralisation of the waste liquid prior to re-injection would precipitate out some metal salts, which would need to be filtered before re-injection, and be disposed of in a solid waste repository.*
> *Also following re-injection it is likely that the re-injection bores would rapidly clog owing to precipitation around the bores, as the injected water and existing acidic water in the aquifer*

interact. Clogging of re-injection wellfields and associated problems with pipelines and pumps may increase the risk of spills due to operational problems with equipment and increased maintenance.

None of the issues raised by the CSIRO amount to compelling reasons to support dumping liquid waste in groundwater. Some of the reasons cited are absurd and cast serious doubt over the credibility of the CSIRO review − for example dust suppression is simple and inexpensive.

Recommendation 25: The Royal Commission should recommend a thorough, independent assessment of the options for managing liquid waste from ISL mines.

Recommendation 26: The Royal Commission should recommend that ISL mines are monitored and if necessary remediated until pre-mining water quality conditions are achieved.

The 2004 CSIRO report states:
"For the Beverley operation, groundwater monitoring is required to be conducted for seven years after mining to demonstrate that their expectations in regard to natural attenuation are being borne out. Research into the use of and ability of chemical amendments to assist with or speed up the processes of natural attenuation processes may be beneficial, especially where the latter may be slow and/or incomplete. This approach may also be of benefit in the case of plant or equipment failure with resultant contamination of soil or shallow aquifers."

Recommendation 27: The Royal Commission should determine whether any follow-up work been done to investigate the potential to assist or hasten attenuation of ISL-contaminated groundwater.

The 7 January 2009 *Beverley Four Mile Project Public Environment Report and Mining Lease Proposal* document (p.7.9, table 7.6) states that there is a 'Moderate' risk of contamination preventing a return to pastoral use. The SA government should insist on a more comprehensive risk assessment including quantitative risk assessment.

Recommendation 28: The Royal Commission should ask ISL mining companies to update their projections on the viability of returning land for pastoral use post-mining, noting that the 2009 *Beverley Four Mile Project Public Environment Report and Mining Lease Proposal* document assessed a 'Moderate' risk of contamination preventing a return to pastoral use.

Other environmental impacts at ISL mines

Another feature of ISL mining is surface contamination from spills and leaks of radioactive solutions. There have been dozens of spills at Beverley, such as the spill of 62,000 litres of contaminated water in January 2002 after a pipe burst, and the spill of 15,000 litres of contaminated water in May 2002.[232]

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[232] 42 incidents at Beverley from 1998−2003 are listed at:
http://minerals.dmitre.sa.gov.au/__data/assets/pdf_file/0011/20540/beverley_reporting.pdf
17 further incidents at Beverley from 2004 onwards are listed at:
http://minerals.dmitre.sa.gov.au/mines__and__developing_projects/approved_mines/beverley/uranium_mine_incident_summary
8 incidents at Beverley North are listed at:
http://minerals.dmitre.sa.gov.au/mines__and__developing_projects/approved_mines/beverley_north/uranium_mine_incident_summary
A total of 11 incidents at Honeymoon are listed at:
http://minerals.dmitre.sa.gov.au/mines__and__developing_projects/approved_mines/honeymoon/honeymoon_uranium_mine_incident_summary
and

Secrecy

The 2003 Senate References and Legislation Committee report raised concerns about Heathgate's secrecy. The report stated:
"Another serious claim made by the ACF concerns the status and release of Heathgate Resources' reports on the Beverley FLTs [Field Leach Trials], including the Groundwater Monitoring Summary. The ACF states that release of these reports under the Freedom of Information Act was delayed by company claims of commercial-in-confidence for more than two years. A successful ACF appeal to the South Australian Ombudsman finally secured the release of some of these reports, the Ombudsman finding that in no case was a commercial-in-confidence claim justified."

1.11 Given current techniques of extraction and milling and their regulation, what are the relevant lessons for the contemporary management of environmental impacts that should be learned from past extraction and milling practices?

Academics Gavin Mudd and Mark Diesendorf summarise the substandard history of uranium mine rehabilitation in Australia (and their paper provides references to detailed supporting literature)[233]:

> *In Australia, there is often a widely held belief that we have been successful in rehabilitating our legacy U projects – but invariably this view is held by those who have never visited these sites. In brief, the major Cold War-era U mines in Australia were the Mary Kathleen, Rum Jungle, Radium Hill-Port Pirie and the Upper South Alligator Valley, with the latter rehabilitated only in the 2000s (after the Coronation Hill saga) while all others were rehabilitated in the mid-1980s. Further small U projects were also developed at Pandanus Creek-Cobar 2, Fleur de Lys, George Creek, Brock's Creek and Adelaide River in the Northern Territory and Myponga in South Australia, though no substantive rehabilitation work is known for each site. The Nabarlek project, which operated from 1979 to 1988, was a 'modern U mine' and approved and operated under strict regulations and supervision, being rehabilitated in the mid-1990s. Other 'modern U mines' are still in operation at Ranger, Olympic Dam and more recently Beverley.*
> *At present, there is no former U project in Australia which can be claimed as a successful, long-term rehabilitation case study – all still require ongoing monitoring and maintenance and some remain mildly to extremely polluting. While this may be rather surprising to many in the general mining industry, there is strong evidence to support such a view:*
> ***Rum Jungle** – despite some $20 million of works, the site remains a major source of extreme acid and metalliferous drainage (AMD) to the Finniss River ... as well as a host ongoing problems such as erosion, weeds, site security and so on. ...*
> ***Mary Kathleen** – the rehabilitation project won an Australian engineering excellence award in 1986, based on predictions of no AMD, low ongoing tailings dam seepage and associated impacts, erosional stability and no metal and radionuclide uptake by vegetation (amongst other aspects). Recent research has shown these assumptions over-estimated the long-term success of rehabilitation, with AMD, tailings seepage, erosion and/or metal-radionuclide uptake impacts now prevalent across relevant parts of the site.*
> ***Radium Hill** – although the waste rock and tailings at Radium Hill are very low in specific activity (~0.04 per cent U3O8), physical dispersal has been occurring despite rehabilitation and the site requires ongoing monitoring and maintenance.*

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http://minerals.dmitre.sa.gov.au/__data/assets/pdf_file/0018/20547/honeymoon_reporting.pdf
[233] Mudd, G M & Diesendorf, M, 2010, Uranium Mining, Nuclear Power and Sustainability - Rhetoric versus Reality. In "Sustainable Mining 2010 Conference", Australasian Institute of Mining and Metallurgy (AusIMM), Kalgoorlie, Western Australia, Australia, August 2010, pp 315-340. https://www.ausimm.com.au/publications/epublication.aspx?ID=5676 Available from Gavin.Mudd@monash.edu

Port Pirie *– this site treated ~152 kt of ore concentrate from Radium Hill, grading about ~0.7 per cent U3O8 and like Radium Hill, still requires ongoing monitoring and maintenance.*
Upper South Alligator Valley *– about 13 U mines and 2 U mills were merely abandoned in the mid-1960s, leaving indigenous (Jawoyn) people and tourists to southern Kakadu at risk of radiation exposure or safety hazards, as well as localised AMD at some former mines (mainly Rockhole). Minor rehabilitation works were undertaken in the late 1980s but were not tasked with complete rehabilitation. Following the blocking of the re-mining of Coronation Hill in 1991 and after considerable negotiation with Jawoyn elders, all rehabilitation work in the valley was finally completed in 2009. The test of time will reveal its degree of success (or otherwise).*
Nabarlek *– a U mine/mill opened in the modern era of strict environmental regulations and yet despite closing in 1988 the site was not rehabilitated until 1995. Although post-closure assessment has shown a reduction in average radon flux from the former ore zone, gamma radiation rates have increased across many parts of the site which formerly showed effectively background levels. Some residual infrastructure still remains idle at Nabarlek, as well as major impacts from weeds and the destruction of the revegetation during recent cyclonic storms.*
The saga of the radium era waste (ie 1910s − 1920s) in suburban ***Hunters Hill*** *in Sydney, still not fully remediated and appropriately managed nearly a century later, is also another telling tale of Australia's failure to manage U mining and milling wastes – even for extremely small sites in full public eye.*
At acid in situ leach projects in South Australia, regulatory approvals allow companies to ignore groundwater remediation after mine closure despite never validating key scientific assumptions and claims concerning groundwater impacts.
Australia's track record on U mine and mill rehabilitation is therefore far from acceptable and remains distant from reasonable expectations of all sites and wastes being physically, chemically, biologically and radiologically stable such that we can be confident of no further monitoring or maintenance.

Some further comments on Port Pirie. June 2012 correspondence from the SA Department of Manufacturing, Innovation, Trade, Resources and Energy states: "The [Port Pirie] site assessment works were undertaken to inform the department in developing the long term planning and management of the sites. As a follow on from these works, the sites are actively monitored to provide additional information to assist with the ongoing development of management plans and potential remediation." Except in the unlikely event that progress has been made since mid-2012, the situation at the Port Pirie site remains unresolved − over 50 years after its closure in 1962. As of July 2015, the SA government website states that "a long-term management strategy for the former site" is being developed.[234]

As with uranium mining sites, so too uranium exploration sites have not been adequately rehabilitated in numerous cases. For example, French company Minatome undertook trial mining at Ben Lomond, near Townsville, in the early 1980s. Federal MP Bob Katter spoke about the deceit surrounding this project in Parliament in 2005.[235] He noted that Minatome initially denied reports of a high-level radioactive spill, but then changed its story and claimed that the spill posed no risk and did not reach the water system from which 210,000 people drank.

Bob Katter told Parliament[236]:
"For the next two or three weeks they held out with that story. Further evidence was produced in which they admitted that it had been a dangerous level. Yes, it was about 10,000 times higher than what the

[234] http://minerals.dmitre.sa.gov.au/mines__and__developing_projects/former_mines/port_pirie_treatment_plant
[235] http://parlinfo.aph.gov.au/parlInfo/search/display/display.w3p;query=Id%3A%22chamber%2Fhansardr%2F2005-11-01%2F0056%22
[236] http://parlinfo.aph.gov.au/parlInfo/search/display/display.w3p;query=Id%3A%22chamber%2Fhansardr%2F2005-11-01%2F0056%22

health agencies in Australia regarded as an acceptable level. After six weeks, we got rid of lie number two. I think it was at about week 8 or week 12 when, as a state member of parliament, I insisted upon going up to the site. Just before I went up to the site, the company admitted − remember, it was not just the company but also the agency set up by the government to protect us who were telling lies − that the spill had reached the creek which ran into the Burdekin River, which provided the drinking water for 210,000 people. We had been told three sets of lies over a period of three months."

The substandard history of uranium mine rehabilitation in Australia means that there is no reason for confidence in future mine rehabilitation.

Adequate rehabilitation of legacy mines discussed above would be a first step to restoring some confidence in the ability of industry and state/federal governments to responsibly manage the closure and rehabilitation.

As Mudd and Diesendorf note (above), not all of the inadequately rehabilitated mines are from the pre-modern era, so the distinction between inadequately rehabilitated pre-modern mines, and adequately rehabilitated modern mines, does not withstand scrutiny.

The funding shortfall for the rehabilitation of the Ranger mine is believed to be between $200 million and $500 million.[237] ERA's parent company Rio Tinto has said that it will meet the shortfall, but the uncertainty surrounding the financing of such a major, known and necessary set of actions further undermines the view that 'modern' practices are adequate.

Recommendation 29: The Royal Commission should recommendation studies into rehabilitation options for disused uranium mines in Australia, the implementation of appropriate measures to reduce public health and environmental hazards, and the status and adequacy of funding mechanisms.

One unsavoury feature of Australia's nuclear history is the exposure of children to radiation at disused uranium mines and processing plants. A number of examples are listed here[238]:

- Due to the lack of fencing, the contaminated Port Pirie Uranium Treatment Complex site was used as a playground by children for a number of years. The situation was rectified only after a six-year community campaign.
- After mining at Rum Jungle in the NT ceased, part of the area was converted to a lake. As a crocodile-free water body in the Darwin region, the site became popular despite the radioactivity.
- In November 2010, the Rum Jungle South Recreation Reserve was closed due to low-level radiation in the area. The Department of Resources advised the local council to shut down the reserve as a precautionary measure.
- In 2012, damage to a security gate allowed children to enter a contaminated site near Kalgoorlie. More than 5,000 tonnes of tailings from the Yeelirrie uranium deposit, near Wiluna, were buried there in the 1980s. BHP Billiton said it would improve security.
- In a 1997 report, WMC admitted leaving the contaminated trial uranium mine at Yeelirrie, WA, exposed to the public with inadequate fencing and warning signs for more than 10 years. A spokesperson for WMC said a 1995 inspection revealed the problems and also admitted that the company could have known about the problems as early as 1992. WMC said there was inadequate signage warning against swimming in a dam at the site, which was found to be about 30 times above World Health Organisation radiation safety standards and admitted that people used the dam for "recreational" purposes including swimming.

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[237] Peter Ker, 15 June 2001, 'ERA shares in death spiral as prospects slashed', www.theage.com.au/business/mining-and-resources/era-shares-in-death-spiral-as-prospects-slashed-20150615-gho6jg.html

[238] For more information and references see the relevant entries at www.australianmap.net

- Children and adults alike have been exposed to radiation from the contaminated uranium processing site at Hunters Hill in Sydney (and children are more susceptible than adults to radiation-induced cancers). Only in recent years has the contamination come to light after decades of deceit and obfuscation. The NSW Health Commission covered up the dangers of Hunters Hill. An internal memo in 1977 told staff to "stall and be non-committal" when responding to queries. Residents were told there was "no logical reason" to carry out radiation or health tests even though the NSW government knew that there were compelling reasons to do so. The site was last used for uranium processing in 1915 − and the situation remains unresolved 100 years later.

1.12 If an expansion of exploration or extraction activities were viable, what would the estimated benefit be expected to be directly in those sectors, in terms of economic activity? Can growth in employment relating to the extraction or milling of uranium (alone or in conjunction with other commodities being extracted) be estimated? Is there evidence increased extraction and milling would create additional capabilities and capacities in related sectors? What are those sectors? What would their value be?

The following comments cover export revenue, jobs, royalties, subsidies, and tax arrangements

Export revenue

It should first be noted that because of the high degree of foreign ownership of companies mining uranium in Australia, figures on export revenue are misleading. Much of that 'export revenue' never comes anywhere near Australia.

Leaving aside the above point, uranium export revenue accounted for 0.29% of national export revenue averaged over the years 2002 to 2011, and the peak was 0.45% in 2009.[239] The figure now stands at <0.2%. Using figures from the 2011/12 financial year, uranium export revenue was 4.4 times lower than Australia's 20th biggest export earner and 8.7 times lower than Australia's 10th biggest export earner.

On the basis of the above data (and other factors such as the failure of the nuclear power renaissance to eventuate, and the ageing of the world's reactor fleet), no matter how much government support is provided, no matter how much already weak environmental standards are weakened, it is extraordinarily unlikely that uranium could reach let alone sustain a 1% contribution to national export revenue (a >5-fold increase on the current figure); it is extraordinarily unlikely that uranium could reach or sustain a place in the top 20 list of export revenue earners; and it is inconceivable that uranium could make the top 10 list of export revenue earners.

The federal and SA governments already permit uranium sales to weapons states, states refusing to sign the NPT (India − the bilateral uranium sales / nuclear cooperation agreement is currently before the federal Joint Standing Committee on Treaties), states refusing to sign and/or ratify the Comprehensive Test Ban Treaty, and repressive regimes (esp. China, UAE) − so there is little room to move in terms of loosening export policy.

[239] ACF, 2013, 'Yellowcake Fever: exposing the uranium industry's economic myths', www.acfonline.org.au/resources/yellowcake-fever-exposing-uranium-industrys-economic-myths

Jobs

According to IBISWorld's March 2015 market report, 987 people are employed in Australia's uranium industry.[240]

The World Nuclear Association (WNA) puts the figure at 1,760 jobs (1,200 in uranium mining, 500 in exploration and 60 in regulation).[241] The World Nuclear Association has provided the same figure for the past five years or so, so at best it could be regarded as indicative.

As of June 2015, 11.77 million people are listed as 'employed persons' by the ABS.[242]

Thus even the higher WNA figure of 1,760 jobs in Australia's uranium industry represents just 0.015% of all jobs in Australia and considerably less than 1% of jobs in mining, oil and gas operations[243] (while all mining accounts for about 2% of total jobs in Australia[244]).

Using the lower figure provided by IBISWorld of 987 jobs in the uranium industry, the industry accounts for <0.01% (0.0084%) of jobs in Australia.

For the uranium industry to account for 1% of jobs in Australia, jobs in the industry would need to increase 67-fold (WNA) to 119-fold (IBISWorld).

Uranium mining is not and never will be a significant source of employment in Australia.

The Minerals Council of Australia claims that 4,200 people are employed in the uranium industry in Australia (0.036% of jobs in Australia).[245] No justification is provided for the figure and it is best regarded as an outlier. The Minerals Council of Australia repeatedly provides a figure of 4,000−4,200 jobs and repeatedly fails to provide any supporting data or references to supporting literature.

The Australian Safeguards and Non-Proliferation office states: "If all employees of Olympic Dam are included as being employed in the uranium industry, the Department of Resources, Energy and Tourism estimates current total direct employment in the Australian uranium industry at 4,200 people."[246]

Counting all employees at Olympic Dam as uranium industry workers is disingenuous. Only a small fraction of the Olympic Dam workforce is directly involved in uranium processing. Uranium accounts for a small fraction of the mine's mineral production volume, revenue, profits, etc. (the Royal Commission could ask BHP Billiton to provide the precise figures).

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[240] IBISWorld, 'Uranium Mining in Australia: Market Research Report', www.ibisworld.com.au/industry/default.aspx?indid=1852 A IBISWorld [Accessed 15 July 2015]

[241] World Nuclear Association, 'Australia's Uranium', updated June 2015, www.world-nuclear.org/info/Country-Profiles/Countries-A-F/Australia--Uranium [Accessed 15 July 2015]

[242] www.abs.gov.au/ausstats/abs@.nsf/mf/6202.0 [Accessed 15 July 2015]

[243] www.canberratimes.com.au/opinion/mining-industrys-big-lie-20120217-1tepr.html

[244] Gareth Hutchens, 20 March 2011, 'Mining companies shedding jobs by the thousands', www.theage.com.au/business/the-economy/mining-companies-shedding-jobs-by-the-thousands-20150319-1m35zx.html
Bernard Keane, 17 Nov 2011, 'Mining industry surges, but we're becoming a service economy', www.crikey.com.au/?p=259686

[245] Minerals Council of Australia, April 2015, 'Uranium: Australia's Next Billion Dollar Industry', www.minerals.org.au/file_upload/files/publications/Uranium_Natural_Energy_FINAL.pdf

[246] ASNO, 23 May 2013, submission to Joint Standing Committee on Treaties, File Number: 11/13328, Submission #11. See also Joint Standing Committee on Treaties, final report on 'Agreement between the Government of Australia and the Government of the United Arab Emirates on Cooperation in the Peaceful Uses of Nuclear Energy (Abu Dhabi, 31 July 2012)'

In addition to providing an inflated figure of 4,200 current jobs in the uranium industry, the Minerals Council of Australia states that, with growth, the industry could generate 10,000 jobs.[247] Again, no justification for the estimate is provided. Does the Minerals Council anticipate the opening of new poly-metallic mines (like Olympic Dam) and does it anticipate counting the entire workforce at those mines as uranium industry workers? If not, how does that Minerals Council arrive at such a fanciful figure?

Recommendation 30: The Minerals Council of Australia should be asked to justify its fanciful figures regarding current and potential future employment by the uranium industry in Australia.

Sometimes a multiplier is used to inflate the employment figures, based on indirect employment. The use of multipliers is questionable as jobs may simply be redistributed rather than being additional jobs.[248]

The defunct Australian Uranium Association claimed the industry is a "significant employers of First Australians, with some workforces comprising up to 15 per cent indigenous employees."[249] If we assume 15% of the uranium workforce are indigenous people, that amounts to 148 jobs using the IBISWorld estimate of 987 total jobs, or one job for every 4,526 indigenous Australians.[250] Most of the jobs for indigenous people in Australia are based at Ranger (around 100 indigenous employees) so the uranium industry's contribution to indigenous employment will be still more insignificant if, as expected, uranium mining and milling ends at Ranger in the coming years.

Royalties

Accurate, up-to-date figures on royalties paid by uranium companies operating in Australia are hard to find. Steve Kidd from the World Nuclear Association wrote in May 2008: "[U]ranium mines generate about A$21 million in royalties each year, with corporate taxes amounting to over A$42 million per year."[251] The $21 million figure may have increased since 2008 if, as the NFCRC Issues Paper #1 states, royalties from uranium mining in SA alone amounted to $16.5 million in 2013/14 (paid to the South Australian government).

In an assessment of the Olympic Dam royalties regime enshrined in the amended SA Roxby Downs Indenture Act, journalist Paul Clearly wrote in *The Australian* in October 2011 that the regime "has robbed the state's citizens and all Australians of the opportunity to share in the profits of what will become the world's biggest mine".[252] He added that the agreement "will unfortunately stand as a sad and enduring indictment of the weakness of our state governments when it comes to negotiating with powerful mining multinationals".

In WA, the Liberal National Government's 'Royalties for Regions' policy was meant to use mining royalties to fund schools, health services and other community infrastructure.[253] But $80 million was redirected to support mineral exploration and a significant amount went to uranium companies despite the promise that the WA government would not fund uranium mining.[254]

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[247] 13 April 2015, www.minerals.org.au/news/new_publication_uranium_australias_next_billion_dollar_industry
[248] Richard Denniss, 18 Feb 2012, 'Mining industry's big lie', www.canberratimes.com.au/opinion/mining-industrys-big-lie-20120217-1tepr.html
[249] http://web.archive.org/web/20120204182049/http://www.aua.org.au/Content/Keyindustryfacts.aspx
[250] Based on an Aboriginal and Torres Strait Islander population of 669,900 www.abs.gov.au/ausstats/abs@.nsf/latestProducts/3238.0.55.001Media%20Release1June%202011
[251] www.neimagazine.com/story.asp?storyCode=2049570
[252] www.theaustralian.com.au/business/opinion/a-case-of-olympian-incompetence-by-south-australia/story-e6frg9if-1226172260137?mid=523
[253] www.rdl.wa.gov.au/royalties/pages/default.aspx
[254] www.dmp.wa.gov.au/7743.aspx

Subsidies

BHP Billiton enjoys extensive subsidies in the form of fuel-tax credits (formerly known as diesel fuel rebates). Under the abandoned mine mega-expansion plan, the company would have enjoyed $350 million in diesel fuel rebates over five years[255] – more than was to be paid to the State in royalties from the existing underground mine over the same period − and an effective subsidy of $85 million annually to 2050.[256] A 2012 Australia Institute report found that at a time when the mining industry is earning record profits, it received subsidies and concessions worth more than $4 billion per year from the Federal Government alone.[257] The biggest single subsidy came in the form of fuel-tax credits, valued at $1.9 billion in 2009/10.

Tax arrangements

Uranium mining companies fought the proposed mining tax in 2010.[258] Ross Gittins wrote in *The Age* in February 2013:
"Last year the mining industry accounted for more than a fifth of all the profit made in Australia, even though it had a much smaller share of the economy. This was mainly because the royalties charged by the state governments failed to capture enough of the market value of the minerals the largely foreign-owned miners were being permitted to extract. When the Rudd government tried to correct this with a resource super profits tax, the industry set out to bring about its electoral defeat."[259]

Uranium was to be included in the proposed Resource Super Profit Tax, but it was subsequently excluded from the Minerals Resource Rent Tax.

A 2011 report by the Australia Institute noted that the average rate of corporate tax paid by the mining industry in 2008/09 was 13.9% − substantially below the theoretical 30%.[260]

Media reports in July 2015 questioned BHP Billiton's tax arrangements. Sydney company director Rod McGeoch hit out at BHP Billiton for using a Singapore company to structure its tax arrangements and called for major Australian companies to drop artificial tax avoidance structures.[261]

Recommendation 31: The Royal Commission should determine whether BHP Billiton and other uranium miners in Australia are using artificial tax avoidance structures, estimate the economic impact of any such structures, and make recommendations accordingly.

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[255] www.acfonline.org.au/news-media/media-release/bhp-olympic-dam-expansion-over-sized-subsidised-and-leaky
[256] www.acfonline.org.au/news-media/opinions/olympic-dam-economics-do-benefits-outweigh-costs-age
[257] https://www.tai.org.au/index.php?q=node%2F19&pubid=986&act=display
[258] 5 May 2010, 'Uranium companies concerned about Resources Super Profits Tax', http://web.archive.org/web/20130409230752/http://aua.org.au/Content/050510AUAViewonSuperProfitsTax.aspx
[259] www.theage.com.au/opinion/politics/the-four-industries-that-rule-australia-20130205-2dwew.html
[260] https://www.tai.org.au/index.php?q=node%2F19&pubid=913&act=display
[261] 15 July 2015, 'Rod McGeoch slams BHP Billiton over Singapore tax -arrangements', The Australian, www.theaustralian.com.au/business/mining-energy/rod-mcgeoch-slams-bhp-billiton-over-singapore-tax-arrangements/story-e6frg9df-1227441954992

1.13 Would an increase in extraction activities give rise to negative impacts on other sectors of the economy? Have such impacts been demonstrated elsewhere in Australia or in other economies similar to Australia?

Examples of negative or potential negative impacts on other sectors include the following.

The 7 January 2009 *Beverley Four Mile Project Public Environment Report and Mining Lease Proposal* (p.7.9, table 7.6) document, prepared by URS for Heathgate Resources, states that there is a 'Moderate' risk of contamination from ISL uranium mining preventing a return to pastoral use.

Contamination around the former uranium mine at Rum Jungle restricts potential uses of the land and has sometimes restricted use of the Rum Jungle South Recreation Reserve. Despite some $20 million of rehabilitation works, the site remains a major source of extreme acid and metalliferous drainage to the Finniss River, as well as a host ongoing problems such as erosion, weeds, site security and so on. In November 2010, the Rum Jungle South Recreation Reserve was closed due to low-level radiation in the area − the Department of Resources advised the local council to shut down the reserve as a precautionary measure. Presumably fishing of the Finniss River has been restricted because of contamination from mine toxins.

A contaminated site near Kalgoorlie is unavailable for alternative uses − and poses an ongoing security / public health problem. In 2012, damage to a security gate allowed children to enter the contaminated site, where more than 5,000 tonnes of tailings from the Yeelirrie uranium deposit were buried in the 1980s. BHP Billiton said it would improve security.

The legacy of multiple uranium mines and two mills in the Upper South Alligator Valley in the Northern Territory has likely restricted tourism and other potential uses of the land.

The controversial Hunters Hill site in Sydney has been disruptive for local residents and one wonders what impact the saga has had on local property prices.

The Port Pirie uranium processing site is off limits for recreational and other uses. Six uranium tailings dams and a rare earth extraction dam cover approximately 26 hectares.[262] A later plan for a rare earths mine was abandoned and the decision to abandon the mine proposal is likely to have been influenced by residual contamination from uranium processing (contamination certainly motivated community opposition to the proposed mine).

BHP Billiton's water take from the Great Artesian Basin for the Olympic Dam mine (the company is licensed to take up to 42 million litres daily) has impacted the Mound Springs (see the references listed in section 1.10) and made them less attractive as a tourist drawcard.

BHP Billiton's water take also competes with local pastoral operations. In August 2014 *The Australian* reported that pastoralist Shane Oldfield from Clayton Station blames BHP Billiton for a local drop in the level of Basin water, requiring the operation and maintenance of pumps which adversely impact on an already marginal operation:[263]

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[262] http://minerals.dmitre.sa.gov.au/mines__and__developing_projects/former_mines/port_pirie_treatment_plant/about_the_plant

[263] Sarah Martin, 9 Aug 2014, 'BHP Billiton's thirst triggers an outback water fight', www.theaustralian.com.au/national-affairs/state-politics/bhp-billitons-thirst-triggers-an-outback-water-fight/story-e6frgczx-1227018481754
See also Michael Owen, 21 Sept 2009, 'Corporate abuse' hits Great Artesian Basin, www.theaustralian.news.com.au/story/0,25197,26101722-5013404,00.html

BHP aren't going to own up to the fact that they are sucking the guts out of the basin," Oldfield said. "But they are. They want the water from this country because without the water they can't mine, and the GAB water is the cheapest water they are ever going to get. Now we have got pumps and it is costing us; when you have got pumps you have got maintenance and you've got running costs and your viability is gone. I've been arguing with BHP for five years, but it's the small bloke against one of the world's biggest companies. They play with blokes like me every day of the week with their fancy lawyers, and the South Australian government doesn't give a shit about the man on the land."

Question 1.13 asks about negative impacts on other sectors from (uranium) extraction activities "in other economies similar to Australia". It is beyond the scope of this submission to answer that question in any detail. One case worth mentioning is the USA, where there are around 10,000 abandoned uranium mines and exploration sites.[264] Currently no laws require cleanup of these sites. Cumulatively, the sites represent a serious public health and environmental hazard, and contamination restricts uses and potential uses of land and water resources.

Another example is competition for limited water resources in Namibia.[265] A November 2013 *Bloomberg* report noted that uranium mines operated by companies including Rio Tinto and Paladin Energy in Namibia faced a water shortage as drought curbs supply to the mines and three coastal towns. Volumes from the Omaruru Delta aquifer declined to four million cubic metres in 2013 from nine million a year earlier. Water from a desalination plant owned by Areva was insufficient to meet the needs of Paladin's Langer Heinrich uranium mine, China Guangdong Nuclear Power Co.'s Husab uranium project and Rio's Rossing complex. Nehemia Abraham, under-secretary for water and forestry in the Ministry of Agriculture, told *Bloomberg*: "The water-supply situation at the coastal area has become too critical. Mining companies in the area will have to operate with less water. We are reviewing the situation now and from end of November we might be unable to get enough water from the aquifer to supply to mines."

Another example concerns the opposition of champagne producers to nuclear waste storage in the Champagne region of France. In the mid 2000s French champagne producers − the Comité Interprofessionnel du Vin de Champagne − unsuccessfully took court action to prevent ANDRA from continuing to store and dispose of low-level radioactive waste at its facility in Soulaines in France's Champagne-Ardenne region. In April 2005, ANDRA informed the French nuclear safety authority that the wall of a storage cell fissured while concrete was added on the last layer of wastes stored in the disposal site. The origin of the fissure was a "water corner" phenomenon resulting from the hydrostatic pressure of a water column formed with the infiltration and which could lead to the breaking of the wall. This event revealed a flaw in the conception of the storage cells of the site.[266]

Trace amounts of the radioisotope tritium were found in wine samples collected near the Hanford nuclear site in Washington State, USA in 2013, and the tritium could have originated from the Hanford Site according to a Department of Energy Report.[267]

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[264] www.cleanupthemines.org
[265] Felix Njini, 19 Nov 2013, 'Rio Tinto, Paladin Namibia Uranium Mines Face Water Shortage', www.bloomberg.com/news/2013-11-18/rio-tinto-paladin-uranium-mines-in-namibia-face-water-shortage.html
[266] Greenpeace, 30 May 2006, 'Radioactive waste leaking into Champagne Water Supply', www.greenpeace.org/international/press/releases/radioactive-waste-leaking-into
World Nuclear News, 22 Oct 2010, 'French waste agency wins case of champagne', www.world-nuclear-news.org/newsarticle.aspx?id=28675
[267] Bill Conroy, 28 March2015, 'Wine Country's Nuclear Threat', www.thedailybeast.com/articles/2015/03/28/hanford-nuclear-site-could-be-threatening-washington-state-s-best-vineyards.html

For some time after the Chernobyl nuclear catastrophe, the French wine industry was depressed because the wine growing regions were in the path of the ionising radiation fallout.[268]

Issues Paper #2: Further Processing of Minerals and Manufacture of Materials Containing Radioactive and Nuclear Substances

The following comments first address the topic of manufacturing materials containing radioactive and nuclear substances, including medical radiopharmaceuticals (questions 2.2, 2.3 and 2.5).

Then questions regarding nuclear fuel cycle processes (conversion, enrichment, fabrication and reprocessing) are addressed (question 2.1, 2.4, 2.6−2.10, 2.13, 2.14).

Then safeguards and security issues are addressed (questions 2.11 and 2.12).

2.2 Would it be feasible for South Australia to assume a greater role in manufacturing materials containing radioactive and nuclear substances? What factors need to be taken in to account in making that determination? Which factors are most important and why?
2.3 What legislative and regulatory arrangements would need to be in place to facilitate further processing and further manufacturing activities, including the transport of the products which they generate? How could these arrangements be developed so that they are most effective?

For security, public health, and environmental reasons, the use of materials containing radioactive and nuclear substances should be subject to rigorous risk−benefit analyses, which would likely lead to a reduction in their use.

Recommendation 32: The Royal Commission should recommend that the SA Government establishes an inquiry into the use of materials containing radioactive and nuclear substances, and consideration of alternatives that may be preferable for security, public health, and environmental reasons.

Some of the issues are addressed in the following article:

> ***Replacing Radioactive Sources***
> *Miles Pomper, 4 Feb 2015,*
> *http://nuclearsecuritymatters.belfercenter.org/blog/finding-alternatives-radioactive-sources*
> *For years, security experts have believed that the most likely form of nuclear terrorism would involve the use of radioactive sources such as "dirty bombs'. Yet, spending by governments, including the U.S. government, to secure or destroy such materials has been paltry. Far higher priority (if still not sufficient) has been accorded to efforts to remove or secure nuclear weapons useable materials, such as highly enriched uranium.*
> *On the one hand, such prioritization is understandable. After all, nuclear weapons could kill tens, or hundreds of thousands of people, while radiological source fatalities might be in the single or double digits. And the expense and difficulty of increasing security for the enormous number of radioactive sources at thousands of civilian facilities around the world—from hospitals to oil wells and industrial sites—is significant.*
> *Nonetheless, the economic, political, and psychological effect of a successful radiological terrorist attack would eclipse any security costs—paralyzing a major city because of the contamination of key areas and deeply wounding the global economy. It therefore make sense to take steps to reduce or eliminate this risk; yet at current spending rates the problem will not be seriously tackled for decades.*

[268] http://wineeconomist.com/2008/01/26/the-science-of-unintended-consequences/

One approach which might resolve this dilemma is to find substitute non-radioactive materials that can serve many of the same useful civil purposes currently carried out with radioactive sources. Support for such an approach has been growing both in the United States and abroad. Seven years ago, at the behest of Congress, the U.S. National Academy of Sciences (NAS) published a landmark report Radiation Source Use and Replacement (www.nap.edu/catalog/11976/radiation-source-use-and-replacement-abbreviated-version). That study examined the feasibility of replacing high-risk radioactive sources with less risky (and most likely non-isotopic) alternatives in order to forestall an act of radiological terrorism. Since then, a quiet behind-the-scenes battle has been waged both in the United States and overseas over how far such efforts should go. Some foreign governments, federal agencies, and U.S states have advocated for a more aggressive approach, concerned both by the threat and the short and long-term financial and practical difficulties of securing the thousands of such high-risk sources from theft or misuse. On the other hand, source manufacturers, and some U.S. government and international agencies have been more cautious, given the many positive benefits these sources provide in fields from medicine to oil and gas exploration and industry. Within the federal government, the ongoing locus of this fight has been the quadrennial report of the interagency Task Force on Radiation Source Protection and Security (www.nrc.gov/security/byproduct/task-force.html), which issued important reports in 2010 and 2014.[1] The 2010 report was a very cautious document, even expressing apprehension about how far to proceed with replacing what the NAS report has signaled out as the biggest risk—the continued use of cesium chloride (particularly in blood irradiators) whose unique characteristics make it especially susceptible to being used by terrorists.

By contrast, the 2014 report was much more aggressive in its approach to substitution and made a number of useful recommendations and has led to the formation of an interagency working group on the matter. At the same time, some members of Congress have been pushing for stronger action. Sen Dianne Feinstein (D-Calif.), then chair of the Senate Energy and Water Appropriations Subcommittee, pushed legislation through the appropriations panel endorsing a timetable for substituting out high-risk sources. After resistance from the House, however, these measures did not make it into the omnibus spending bill Congress passed last fall.

International support for replacing high-risk sources has also been growing. In its progress report (www.nss2014.com/sites/default/files/documents/united_states_of_america.pdf) to the 2014 Nuclear Security Summit (NSS), the United States says that it "intends to establish an international research effort on the feasibility of replacing high-activity radiological sources with non-isotopic replacement technologies, with the goal of producing a global alternative by 2016." France, in its National Statement (www.nss2014.com/sites/default/files/documents/national_statement_france.pdf) to the 2014 NSS calls for "minimizing the use of high activity sealed sources where it is technically and economically feasible," citing its use of x-rays rather than cesium chloride in blood irradiators as an example. Other governments—from Norway to Japan—have taken similar steps when it comes to cesium chloride and are looking at other materials.

At the 2014 International Atomic Energy Agency (IAEA) General Conference, Energy Secretary Ernie Moniz announced that the United States had committed to work jointly with France, the Netherlands and Germany to establish a roadmap of action that would include support alternatives for radioactive sources. They and other governments should bring a "gift basket" to the 2016 NSS in which they agree to take measures to substitute non-isotopic alternatives for high-risk sources in order to permanently reduce the threat of radiological terrorism.

[1] The task force is headed by the Nuclear Regulatory Commission and includes 14 federal agencies and one State organization The 2010 and 2014 task force reports and additional information on the task force and their implementation are available at http://www.nrc.gov/security/byproduct/task-force.html

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2.5 Could South Australia viably increase its participation in manufacturing materials containing radioactive and nuclear substances? Why or why not? What evidence is there about this issue? What new or emerging technologies are being developed which might impact this decision?

A step-change is required to reduce or possibly end the reliance on research reactors to produce medical radiopharmaceuticals, by expanding the use of particle accelerators (in particular cyclotrons) and possibly other technologies (e.g. spallation sources). The reasons are as follows:

- Research reactors have a track record of use in weapons programs, with India and Israel being the most notorious cases.[269]
- There have been 4+ fatal research reactor accidents, but no fatal accelerator / cyclotron accidents. Fatal research accidents include: SL-1, USA, 1961 (three fatalities); Boris Kidric Institute, Yugoslavia, 1958 (one fatality); critical assembly reactor, Argentina, 1983 (one fatality); Experimental Test Reactor Building, Idaho National Engineering and Environmental Laboratory, USA, 1998 (carbon dioxide poisoning caused "one death and several life-threatening injuries" according to the Department of Energy[270]).
- The waste stream from accelerators / cyclotrons is less problematic than the waste stream from reactors (spent fuel from ANSTO's OPAL reactor, as with many other research reactors, meets the radiological and heat criteria for classification as high level waste when it is first removed from the reactor and for some time thereafter, whereas accelerators do not produce high-level nuclear waste).

Of particular significance is non-reactor production of technetium-99m (Tc-99m), the isotope used in 70−80% of diagnostic nuclear imaging procedures (and imaging accounts for the overwhelming majority (>90%) of nuclear medicine procedures). Only a handful of research reactors around the world produce molybdenum-99 (Mo-99), the parent of Tc-99m. The supply chain has been vulnerable to interruptions from unplanned reactor outages.

Numerous non-reactor methods of Mo-99/Tc-99m production have been proposed over the past few decades, and some methods have been proven on an experimental scale.[271]

A research team at the University of British Columbia is making progress developing non-reactor methods to produce Tc-99m. Using its Triumf cyclotron, they produced enough Tc-99m in six hours to enable about 500 scans, thereby creating a "viable alternative" to the NRU research reactor. Clinical trials involving 50−60 patients are expected to begin this year to prove that the cyclotron-produced Tc-99m behaves in the same way as that from nuclear reactors. If the three-month trials are successful, the university says, one of Triumf's cyclotrons "would likely be dedicated to medical isotope production", possibly as soon as 2016.[272]

The Canadian government has invested around C$60 million in projects, including Triumf, to bring non-reactor-based isotope production technologies to market through its Isotope Technology Acceleration Program initiative.

Production of Tc-99m using cyclotrons does not require the highly enriched uranium targets that are commonly used in reactors to produce Mo-99 (and Mo-99 production has sometimes been used to justify

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[269] http://foe.org.au/sites/default/files/ResearchReactors-Weapons.doc
[270] DoE, 22 Sept 1998, "Energy Department Investigation Finds INEEL Fatal Accident Was Avoidable".
[271] www.foe.org.au/anti-nuclear/issues/oz/lh/tc99
[272] WNN, 9 Jan 2015, 'New record for cyclotron isotope production', www.world-nuclear-news.org/RS-New-record-for-cyclotron-isotope-production-0901158.html

the use of highly enriched reactor fuel). Instead, Tc-99m is produced by bombarding a Mo-100 target with a proton beam.

Another technique that is showing some promise uses the Canadian Light Source in Saskatoon, Saskatchewan.[273] The accelerator bombards a target of enriched Mo-100 with high-energy X-rays, which knock a neutron out of some of the Mo-100 atoms to produce Mo-99. If all goes to plan, two or three accelerator systems like the Canadian Light Source facility could produce enough isotopes to supply Canada's domestic needs. Production of the parent isotope Mo-99 is preferable to direct production of Tc-99, as its longer half-life (66 hours vs. 6 hours for Tc-99m) facilitates more widespread distribution.

If relevant institutions (and researchers) in South Australia believe they can play a role in R&D regarding accelerator production of medical radiopharmaceuticals (esp. Mo-99/Tc-99m), they should be supported. It may be the case that SA does not have the capacity (i.e. accelerator-based R&D capacity) to play a useful role in expanding accelerator production of medical radiopharmaceuticals. Relevant institutions might also be asked if they believe that non-reactor based nuclear medicine is receiving the support it deserves (e.g. cyclotron production of FDG, which can in some cases substitute for Tc-99m).

Logically, ANSTO should be taking leading R&D into non-reactor production of Mo-99/Tc-99m, but ANSTO has done no R&D along those lines.

[273] WNN, 17 Nov 2014, 'Canada ships first synchrotron isotopes', www.world-nuclear-news.org/RS-Canada-ships-first-synchrotron-isotopes-1711148.html

NUCLEAR FUEL CYCLE − CONVERSION, ENRICHMENT, FABRICATION AND REPROCESSING

These topics are addressed under the following subheadings:

- Conversion, enrichment, and fuel fabrication − feasibility
- Australia's 'natural advantage'?
- The Switkowski Review
- BHP Billiton's submission to the Switkowski Review
- Conversion
- Enrichment − viability
- Enrichment and proliferation
- Enrichment − depleted uranium waste
- Enrichment − Silex
- Fuel fabrication
- Reprocessing
- Fuel leasing

The economic case for pursuing conversion, enrichment and fuel fabrication is very weak. That being the case, the economic case for fuel leasing arrangements is also very weak. Likewise, reprocessing is an economic non-starter. For those reasons, no comment is offered in response to some of the questions in Issues Paper #2 − concerning 'best practice' facilities and less successful examples; building community confidence; health and safety; environmental risks; lessons from past South Australian processing practices (see 1.11 and 1.13); and impacts on other sectors of the economy.

2.1 Could the activities of conversion, enrichment, fabrication or reprocessing (or an aspect of those activities) feasibly be undertaken in South Australia? What technologies, capabilities or infrastructure would be necessary for their feasible? How could any shortcomings be addressed?
2.4 What are the projections for future supply and demand for conversion, enrichment, fuel fabrication or reprocessing activities? What is the evidence to support those projections? Might it be viable for one or more of those activities, or an aspect of them, to be established in South Australia in the medium or long term? What is the reason for thinking that would be so? What conditions would be necessary for that to be viable?
2.13 What financial or economic model or method ought be used to estimate the economic benefits from South Australia's establishment and operation of facilities for the conversion, enrichment, fuel fabrication or reprocessing of, or the manufacture of materials containing, radioactive and nuclear substances? What information or data (including that drawn from actual experience elsewhere) should be used in that model or method?

Conversion, enrichment, and fuel fabrication − feasibility

It might be feasible to build facilities for conversion, enrichment, or fuel fabrication in South Australia. However:

- Support from foreign companies/utilities would likely be required − to access proprietary technology, expertise, experience, capital, etc. Establishing university and other training courses to develop a local specialist workforce would be expensive and slow (and to the extent that the cost was covered by governments/taxpayers, it would necessarily have opportunity costs associated with it).
- It is unlikely that developing those facilities would be profitable (see below). Market opportunities will be limited unless there is a major expansion of nuclear power globally − and that is highly unlikely in the foreseeable future. China − the one and only country building large numbers of reactors − is more likely to make use of existing nuclear fuel cycle infrastructure and to further develop its own fuel cycle facilities.

- Nuclear fuel cycle facilities would result in waste legacies such as depleted uranium.
- The promotion of proliferation sensitive technologies would likely arouse regional suspicion and concerns.

Australia's 'natural advantage'?

Nuclear lobbyists sometimes argue that Australia would be well placed to service nuclear power reactors in south-east Asia with front-end fuel cycle services (uranium, conversion, enrichment, fuel fabrication); i.e. Australia's geographical proximity to south-east Asian nations provides a natural advantage. That argument would carry a little more weight if there were any power reactors in south-east Asia. Even if there were any power reactors in south-east Asia, Australia's relative proximity would either be a i) negligible advantage or ii) no advantage at all.

Nuclear lobbyists sometimes argue that, as a miner of uranium, Australia has a 'natural advantage' with respect to the development of front-end nuclear fuel cycle services (often such arguments are framed as 'value adding' to uranium mining). However:

- It is by no means clear that having an Australia source of uranium would be advantageous for a South Australian-based uranium enrichment plant or other front end fuel cycle services. Such facilities could just as easily operate without an Australian source of uranium.
- Uranium mining companies operating in Australia may or may not choose to collaborate with conversion / enrichment / fuel fabrication companies operating in South Australia (and since the uranium mining companies are mostly foreign-owned we should not expect that patriotic fervour would lead them to favour collaboration with Australia-based companies). In any case uranium companies have little or no say over the processing of sold uranium − such decisions are made by nuclear power utilities. As BHP Billiton noted in its submission to the Switkowski Review: *"[U]tilities typically acquire U3O8 and then contract directly with established conversion, enrichment and fuel fabrication service suppliers to meet their specific technical specifications for long periods and often spread supply agreements across a number of suppliers."*[274]
- BHP Billiton (and presumably other miners) opposes any plan to force them into any sort arrangement (e.g. fuel leasing or variations thereof) that would limit its options (or its customers' options).

The Switkowski Review

The 2006 Switkowski Review[275] (a.k.a. Uranium Mining, Processing and Nuclear Energy Review) was highly sceptical about the potential for Australia to develop conversion, enrichment, fuel fabrication or reprocessing plants. Very little has changed since the Switkowski Review. In particular, nuclear power has been stagnant for the past two decades.

The Switkowski Review said[276]:

"The commercial viability and international competitiveness of a new plant in any part of the nuclear fuel cycle will depend on factors such as capital cost, operating costs, the ability to access technology on competitive terms, the state of the international market, access to the required skill base and the regulatory environment. In the case of enrichment, there are also issues associated with the storage of depleted uranium and nuclear non-proliferation."

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[274] BHP Billiton submission to Switkowski Review: http://web.archive.org/web/20070830182528/www.pmc.gov.au/umpner/submissions/

[275] Switkowski Review, 2006, 'Uranium Mining, Processing and Nuclear Energy Review', http://pandora.nla.gov.au/tep/66043

[276] Switkowski Review, 2006, 'Uranium Mining, Processing and Nuclear Energy Review', http://pandora.nla.gov.au/tep/66043

"Establishment of conversion is only likely to be attractive if it is associated with enrichment."
"The enrichment market is very concentrated, structured around a small number of suppliers in the United States, Europe and Russia. It is characterised by high barriers to entry, including limited and costly access to technology, trade restrictions, uncertainty around the future of secondary supply and proliferation concerns."

The Switkowski Report concluded that *"there may be little real opportunity for Australian companies to extend profitably"* into enrichment and that *"given the new investment and expansion plans under way around the world, the market looks to be reasonably well balanced in the medium term."*

"Fuel fabricators are typically associated with reactor vendors, who supply the initial core and in many cases refuel the reactor."
"The WNA [World Nuclear Association] forecasts that fuel fabrication capacity for all types of LWRs significantly exceeds demand ..."

"The complexity of reprocessing plants involving remote handling of highly radioactive and corrosive materials requires expensive facilities and many highly trained staff. ... The only recently constructed commercial scale reprocessing plant (Rokkasho) is estimated to have cost approximately US$18 billion."
"Reprocessing in Australia seems unlikely to be commercially attractive, unless the value of the recovered nuclear fuel increases significantly."

BHP Billiton's submission to the Switkowski Review

BHP Billiton stated in its submission[277] to the Switkowski Review:

"Enrichment has massive barriers to entry − including access to technology and approvals under international protocols − and is concentrated with 4 large players: USEC, Areva, Urenco and Tenex, located within the nuclear weapon states of the United States, the United Kingdom, France and Russia respectively. ... We do not believe that conversion and enrichment would be commercially viable in Australia. ... The economics of any Australian conversion, enrichment or fabrication do not look positive, either individually or collectively. The global market is currently well supplied by services providers with strong customer relationships, economies of scale and scope, the necessary deep technological expertise and experience, solid reputations for delivery, and expansion plans in place."

BHP Billiton's major uranium customers *"have choices about where to acquire their U3O8"* and *"these utilities generally regard their spent fuel as an asset − a resource for future reprocessing to produce more fuel input."*

"BHP Billiton believes that there is neither a commercial nor a non-proliferation case for it to become involved in front-end processing or for mandating the development of fuel leasing services in Australia. ... We do not believe that conversion and enrichment would be commercially viable in Australia. Nor do we believe any government imposed requirement to lease fuel, as distinct from acquiring uranium would be acceptable to its major customers, all of whom have alternative choices about where to acquire their U3O8."

[277] BHP Billiton submission to Switkowski Review:
http://web.archive.org/web/20070830182528/www.pmc.gov.au/umpner/submissions/223_sub_umpner.pdf

"BHP Billiton has no intention to use the [Olympic Dam] mine as a basis to begin providing fuel leasing, conversion, enrichment, nuclear power or national or international waste disposal/storage services. ... [U]tilities typically acquire U3O8 and then contract directly with established conversion, enrichment and fuel fabrication service suppliers to meet their specific technical specifications for long periods and often spread supply agreements across a number of suppliers. Customers value this flexibility and choice. ... There is little evidence of a preference for purchasing a "bundled" supply of U3O8, conversion, enrichment and fuel fabrication services and no established market for fuel leasing."

"There is no evidence that a change to current Australian Government policies to facilitate domestic enrichment, fuel leasing and high level waste disposal would lead to significant economic opportunities or reduce proliferation risks in the foreseeable future. ... It would also put at risk our reputation with customers of being a reliable supplier of uranium concentrates and our ability to enter into the long term supply arrangements that underpin expansion of uranium mining. Noting that a nuclear fuel leasing industry − if permitted by the regulatory framework − is most unlikely to be commercially viable, BHP Billiton would strongly oppose any policies to artificially support the premature development of such an industry by requiring BHP Billiton's customers to use Australian conversion, enrichment or fabrication services − or to quarantine reserves to underpin such a domestic capacity in the future. It would put customer relations and the investments those underpin at risk."

Conversion

The IAEA's 'Nuclear Technology Review 2015' notes that six countries (Canada, China, France, Russia, the United Kingdom and the USA) operate commercial scale plants for the conversion of triuranium octaoxide (U3O8) to uranium hexafluoride (UF6), and small conversion facilities are in operation in Argentina, Brazil, Iran, Japan and Pakistan.[278]

Russia is said to be planning a new conversion plant according to the IAEA report. However it would be no surprise if the project was delayed or abandoned given the surplus of global conversion capacity and the generalised slow-down of Russia's civil nuclear program, with lowered projections and delays already affecting uranium mining[279] and nuclear power plans.[280]

The IAEA report further notes that total world annual conversion capacity has remained constant at around 76,000 t U as UF6 per year, while total current demand for conversion services (assuming an enrichment tails assay of 0.25% uranium-235) is in the range of 60,000–64,000 tonnes per year.

There is no reason to believe that uranium conversion would be a viable industry in Australia.

Enrichment − viability

The establishment of a uranium enrichment industry in SA is being promoted as a way to 'value add' to uranium exports. For example Stefaan Simons from the (industry-funded) University College London claims that "an Australian nuclear enrichment industry, depending on the scale, could generate up to $4

[278] IAEA, July 2015, Nuclear Technology Review 2015, www.iaea.org/About/Policy/GC/GC59/GC59InfDocuments/English/gc59inf-2_en.pdf
[279] Reuters, 13 Nov 2013, 'Russia's Rosatom to mothball uranium mine expansion projects', www.reuters.com/article/2013/11/13/russia-rosatom-idUSL5N0IY1E720131113
[280] Jim Green, 11 June 2015, 'Russia's nuclear slow-down', Nuclear Monitor #805, www.wiseinternational.org/nuclear-monitor/805/nuclear-monitor-805 [Available from monitor@wiseinternational.org]

billion of investment (from one plant), 600 construction jobs and provide up to 400 new permanent jobs over the next 30 years."[281]

More likely, it would be a very expensive white elephant.

The IAEA's 'Nuclear Technology Review 2015' states that total global enrichment capacity is currently about 65 million separative work units (SWUs) per year, compared to a total demand of approximately 49 million SWUs per year.[282] Commercial enrichment services are carried out by five companies: the CNNC (China), AREVA (France), Rosatom (Russia), USEC (USA) and URENCO (both Europe and the USA), and there are small enrichment facilities in Argentina, Brazil, India, Iran, Japan and Pakistan.

The NFCRC Issues Paper #2 references a World Nuclear Association report (available at great cost from the Association) which states that in its 'high' case there will be unmet demand for conversion and enrichment by 2030.[283] That would only be the case if there was an improbably large expansion of global nuclear power. To the extent that there is any requirement for new facilities in the foreseeable future, there are, as BHP Billiton noted in relation to enrichment, "massive barriers to entry" and it is far more likely that new facilities would be built in countries with existing technology rights, sites, trained staff, experience, legal and regulatory infrastructure, established customers, etc.

The NFCRC Issues Paper #2 states that the Switkowski Review[284] "estimated that Australia's annual export revenue could be increased by $1.8 billion at that time if the then estimated 12,000 tonnes of uranium oxide was transformed domestically into nuclear fuel." Uranium production was less than half that level (5897 t U3O8) in 2014.[285] Moreover, the NFCRC is selective in its use of the Switkowski Review, which qualifies the $1.8b estimate with the following comments:

- "However, high commercial and technology barriers could make market entry difficult. Current legal and regulatory impediments would need to be removed, but there may be little real opportunity for Australian companies to extend profitably into these areas."
- "However, challenges associated with the required investment levels and access to enrichment technology are very significant."
- "The net economic benefit would require a full consideration of costs."

The Switkowski Review further said:[286]
"The enrichment market is very concentrated, structured around a small number of suppliers in the United States, Europe and Russia. It is characterised by high barriers to entry, including limited and costly access to technology, trade restrictions, uncertainty around the future of secondary supply and proliferation concerns."

The Switkowski Review concluded that *"there may be little real opportunity for Australian companies to extend profitably"* into enrichment and that *"given the new investment and expansion plans under way around the world, the market looks to be reasonably well balanced in the medium term."*

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[281] Andrew Hough, 18 Aug 2013, 'Nuclear enrichment industry could lead to multi-billion-dollar economic bonanza, study says', The Advertiser, www.adelaidenow.com.au/business/nuclear-enrichment-industry-could-lead-to-multibilliondollar-economic-bonanza-study-says/story-fni6uma6-1226699572009
[282] IAEA, July 2015, Nuclear Technology Review 2015, www.iaea.org/About/Policy/GC/GC59/GC59InfDocuments/English/gc59inf-2_en.pdf
[283] World Nuclear Association, 2013, 'The Global Nuclear Fuel Market: Supply and Demand 2013-2030', http://online-shop.world-nuclear.org/bfont-size18pxthe-global-nuclear-fuel-market-supply-and-demand-2013-2030fontb-10-p.asp
[284] Switkowski Review, 2006, 'Uranium Mining, Processing and Nuclear Energy Review', http://pandora.nla.gov.au/tep/66043
[285] World Nuclear Association, 23 Jan 2015, Weekly Digest, http://us1.campaign-archive1.com/?u=140c559a3b34d23ff7c6b48b9&id=e08ac096b6&e=ae5ca458a0
[286] http://pandora.nla.gov.au/tep/66043

BHP Billiton's submission to the Switkowski Review stated:[287]
"Enrichment has massive barriers to entry − including access to technology and approvals under international protocols − and is concentrated with 4 large players: USEC, Areva, Urenco and Tenex, located within the nuclear weapon states of the United States, the United Kingdom, France and Russia respectively. ... We do not believe that conversion and enrichment would be commercially viable in Australia. ... The economics of any Australian conversion, enrichment or fabrication do not look positive, either individually or collectively. The global market is currently well supplied by services providers with strong customer relationships, economies of scale and scope, the necessary deep technological expertise and experience, solid reputations for delivery, and expansion plans in place."

Then foreign minister Alexander Downer said in 2007 that uranium enrichment *"would have to be commercially viable and I am advised that quite apart from having to work pretty hard to persuade the United States that Australia should enrich uranium ... it would take some persuading to convince other countries to feel comfortable with that. I'm not sure that [enrichment] would be commercially viable either. Quite apart from the political obstacles, I think there are a lot of commercial obstacles as well."*[288]

Conditions are no more conducive to the establishment of an enrichment industry now than they were in 2006/07. As mentioned, the IAEA's 'Nuclear Technology Review 2015' states that total global enrichment capacity is currently about 65 million SWUs per year compared to a total demand of approximately 49 million SWUs.[289]

In March 2015, Dr Switkowski said: "There's a lot of enrichment capacity around the world. It's a tightly controlled technology, it's the area where Iran is creating so much drama globally because if you get involved in enrichment, you are presumed to have the capacity to enrich to military grade."[290]

Former Western Mining Corporation executive Richard Yeeles said in February 2015: "I think there is over-capacity around the world for conversion and enrichment."[291]

Former World Nuclear Association executive Steve Kidd noted in *Nuclear Engineering International* in July 2014 that "the world enrichment market is heavily over-supplied".[292] Kidd wrote:
"The shutdown of reactors in Japan has not helped the supply-demand balance in the market, but it is clear that the producers have been over-optimistic about enrichment demand (in common with the uranium market) in the medium term. The mooted nuclear renaissance has clearly stalled and there are now substantial doubts about the level of future demand in US and western European markets. The commissioning of new reactors is unlikely to offset the number of closures (for economic or, in the case of Europe, sometimes political reasons) so this over-capacity could remain for some time. Rapidly rising Chinese demand for nuclear fuel could offer a possible market, but it is generally expected that the Chinese will increase their domestic enrichment capacity to meet demand."

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[287] http://web.archive.org/web/20070830182528/www.pmc.gov.au/umpner/submissions/223_sub_umpner.pdf
[288] Katharine Murphy, 6 Sept 2007, 'Australia stakes its claim to uranium enrichment', www.theage.com.au/news/national/australia-stakes-its-claim-to-uranium-enrichment/2007/09/05/1188783321096.html
[289] IAEA, July 2015, Nuclear Technology Review 2015, www.iaea.org/About/Policy/GC/GC59/GC59InfDocuments/English/gc59inf-2_en.pdf
[290] Cameron England, 6 March 2015, 'Ziggy Switkowski says nuclear power and waste storage to play a big part in South Australia's future', The Advertiser, www.adelaidenow.com.au/news/south-australia/ziggy-switkowski-says-nuclear-power-and-waste-storage-to-play-a-big-part-in-south-australias-future/story-fni6uo1m-1227252018665
[291] ABC, 16 Feb 2015, 'Nuclear waste dump has potential to earn SA billions of dollars: Ziggy Switkowski', www.abc.net.au/news/2015-02-16/nuclear-waste-has-potential-to-earn-sa-billions-ziggy-switkowski/6115694
[292] Steve Kidd, 4 July 2014, 'Uranium enrichment – what's happening today?', www.neimagazine.com/opinion/opinionuranium-enrichment-whats-happening-today-4311115/

Likewise Silex Systems CEO Michael Goldsworthy said in July 2014 that "enrichment services are in significant oversupply."[293]

Several building, rebuilding, and expansion plans are mentioned in the IAEA's 'Nuclear Technology Review 2015': [294]

- Argentina is rebuilding its gaseous diffusion capacity at Pilcaniyeu.
- URENCO USA has begun construction on Phase III, which will increase current capacity of 3.7 million SWUs to 5.7 million SWUs.
- Additional enrichment plants are planned in the US: AREVA is planning to build a 3.3 million SWUs centrifuge plant at Eagle Rock in Idaho; Global Laser Enrichment is planning a 6 million SWUs laser enrichment plant in Wilmington, North Carolina; and USEC's American Centrifuge Plant, which was put on hold in 2009, will start a new R&D programme, the American Centrifuge Technology Demonstration and Operations Program, which will be carried out until the end of 2015 and is intended to maintain the American Centrifuge Project technology and remedy certain technical shortcomings that appeared in 2014 with the ACP centrifuges.

However the IAEA report fails to note that, according to Areva, the Eagle Rock "project has been placed on hold temporarily because of short-term uncertainties regarding its overall financing".[295] Likewise, the laser enrichment plant in Wilmington (discussed below), and USEC's American Centrifuge Plant[296], may not proceed.

Former World Nuclear Association executive Steve Kidd discusses some of the political considerations in the US:[297]

> *Finally, one important issue in the US in the context of the future of USEC and the SILEX project is whether it is advisable for the country not to have a domestically-owned enrichment plant. A return to a nuclear arms race may seem unlikely, but the recent tensions over Ukraine give ammunition to those in Washington who claim that the US must retain a domestically-owned facility.*
>
> *The trend in recent years has been to reduce the number of nuclear weapons through arms-limitation agreements with Russia, but some argue that this may one day be reversed. One option in that eventuality would surely be to nationalise the New Mexico plant owned by Urenco and turn it over to the military, but this is still deemed to provide the US with too little security by some lobbyists. There would therefore be some pressure for the US to establish a new enrichment facility owned either by the US government or a private US company. This could be either a SILEX or ACP plant (or conceivably some other technology if the US could license the Urenco or Russian technology). Any such plant would, however, be a politically-inspired creation and (if subsidised by the US government) arguably harmful to the interests of the commercial enrichment suppliers.*

Enrichment and proliferation

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[293] Silex Systems, 24 July 2014, 'GLE Restructures to Align with Adverse Market Conditions', http://asxcomnewspdfs.fairfaxmedia.com.au/2014/07/24/01535857-314409088.pdf

[294] IAEA, July 2015, Nuclear Technology Review 2015, www.iaea.org/About/Policy/GC/GC59/GC59InfDocuments/English/gc59inf-2_en.pdf

[295] Areva, Eagle Rock Enrichment Plans, www.areva.com/EN/operations-779/the-eagle-rock-project-construction-of-an-enrichment-plant-in-the-united-states.html [Accessed 24 July 2015]

[296] Reuters, 16 Dec 2013, 'Uranium company USEC says expects to file for bankruptcy', http://uk.reuters.com/article/2013/12/16/usec-bankruptcy-idUKL3N0JV2CI20131216

[297] Steve Kidd, 4 July 2014, 'Uranium enrichment – what's happening today?', www.neimagazine.com/opinion/opinionuranium-enrichment-whats-happening-today-4311115/

If there was an economic case for enrichment in Australia, it should still be rejected because it provides a direct link to fissile material for weapons (highly enriched uranium), because Australia's active support for and reliance on (US) nuclear weapons is well-known and Australia is thus regarded as untrustworthy regarding nuclear weapons proliferation[298], and because Australia's development of enrichment would encourage other countries (e.g. Indonesia) to develop a fissile material production capability and more broadly it would undermine efforts to stop the spread of 'sensitive nuclear technologies' (enrichment and reprocessing).

Dr Dewi Anwar, a former State Secretary for Foreign Affairs in the Indonesian government, said in 2006:
"I think it's very important that Australia does assure the international community that it will not add another security threat to the already very unstable global situation at the moment. Indonesia and the ASEAN countries would probably be concerned about Australia doing uranium enrichment until we get more details of it."[299]

Prof. Hugh White noted in a 2007 article:
"No matter what we think, and no matter what we say, a decision to develop uranium enrichment capability in Australia would be seen by our neighbours as a short cut to nuclear weapons. We would need to think very carefully about how they might respond."[300]

George Perkovich from the Carnegie Endowment for International Peace states:
"Enriching uranium is probably the easiest way for a country to build nuclear weapons secretly. It's not easy ... but it's harder to detect and produces highly enriched uranium which is easier to turn into weapons. And so there is a real concern when enrichment capability spreads around the world or goes to another place."[301]

Andrew Davies from the Australian Strategic Policy Institute notes that:
"[I]t is not always intent that is factored into strategic calculations, but sometimes capability. That is much harder to argue against. Other nations might reasonably conduct their strategic planning based on what we can do rather than what we say. What is true of [enrichment] technology *developed in Iran is also true of technology developed within Australia. Regardless of our motives, our capability to develop nuclear arms would be enhanced."*[302]

Australia's involvement in enrichment R&D began in 1965 with the 'Whistle Project' in the basement of Building 21 at Lucas Heights, then run by the Australian Atomic Energy Commission.[303] Those in the know were supposed to whistle as they walked past Building 21 and say nothing about the secret

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[298] See for example:
Australia's Nuclear Shame, Part I: Undermining the South Pacific Nuclear Weapons Free Zone
www.foe.org.au/undermining-south-pacific-nuclear-weapons-free-zone
Australia's Nuclear Shame, Part II: Undermining the Nuclear Non-Proliferation Treaty (Dave Sweeney)
www.foe.org.au/undermining-nuclear-non-proliferation-treaty
Australia's Nuclear Shame, Part III: Undermining nuclear disarmament diplomacy
www.foe.org.au/undermining-nuclear-disarmament-diplomacy
[299] ABC, 2006, 'Australia and the nuclear renaissance', 'Background Briefing',
www.abc.net.au/rn/backgroundbriefing/stories/2006/1726921.htm
[300] Hugh White, 1 March 2007, 'Don't mention the bomb', www.theage.com.au/news/hugh-white/dont-mention-the-bomb/2007/02/28/1172338702694.html
[301] ABC, 2006, 'Australia and the nuclear renaissance', 'Background Briefing',
www.abc.net.au/rn/backgroundbriefing/stories/2006/1726921.htm
[302] Andrew Davies, 1 Sept 2006, 'We should be wary of a nuclear reaction', www.smh.com.au/news/opinion/we-should-be-wary-of-a-nuclear-reaction/2006/08/31/1156817030889.html
[303] www.foe.org.au/anti-nuclear/issues/oz/ozbombs/

enrichment R&D. There was undoubtedly a weapons agenda underpinning the enrichment R&D. The enrichment R&D was publicly revealed in the Australian Atomic Energy Commission's 1967-68 Annual Report and plodded along until it was terminated in the mid-1980s.

Enrichment − depleted uranium waste

Depleted uranium (DU) is a radioactive by-product of the uranium enrichment process. It gets its name from the fact that much of the uranium-235 has been extracted from it. When natural uranium is enriched, around one-seventh of the original amount becomes enriched uranium fuel and the remainder is DU waste. Thus very large stockpiles of DU waste have been created − the figure is approaching two million tonnes according to a 2014 article in *Nuclear Engineering International*.[304]

Peter Diehl from the World Information Service on Energy summarises storage and disposal issues associated with DU:
"Most of the depleted uranium produced to date is being stored as UF6 in steel cylinders in the open air in so-called cylinder yards located adjacent to the enrichment plants. ... Chemically, UF6 is very reactive: with water it forms the extremely corrosive hydrofluoric acid and the highly toxic uranyl fluoride (UO2F2). The hydrofluoric acid causes skin burns, and, after inhalation, damages the lungs. Further health hazards result from the chemical toxicity of the uranium to the kidneys, and from the radiation of the uranium (an alpha emitter). In the storage yards, the cylinders are subject to corrosion. The integrity of the cylinders must therefore be monitored and the painting must be refreshed from time to time. This maintenance work requires moving of the cylinders, causing further hazards from breaching of corroded cylinders, and from handling errors. ... For long-term storage or disposal, the depleted UF6 must be converted to a less reactive chemical form: candidates are UF4, U3O8, and UO2."[305]

DU is used in munitions (e.g. missile nose cones) used to pierce armour plating. It has been used in munitions used by the US and NATO in Iraq, the Balkans and Afghanistan. This has generated controversy because of the long-term public health and environmental risks associated with DU.[306]

Because DU is rich in uranium-238, it is ideal for producing fissile plutonium-239 for use in nuclear weapons. This can be done by inserting a 'blanket' or target into a reactor − of particular concern are fast neutron reactors designed to 'breed' fissile material by irradiating blankets/targets comprising fertile isotopes (uranium-238 or thorium-232).

For more information on DU and enrichment plants see Arjun Makhijani and Brice Smith, 2005, 'Costs and Risks of Management and Disposal of Depleted Uranium', www.ieer.org/reports/du/LESprfeb05.html

For more information on the hazards associated with uranium hexafluoride see the WISE-Uranium resources: www.wise-uranium.org/euf6h.html

Enrichment − Silex

The IAEA's 'Nuclear Technology Review 2015' states that Global Laser Enrichment is planning a 6 million SWUs laser enrichment plant in Wilmington, North Carolina.[307]

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[304] Steve Kidd, 6 May 2014, 'The future of uranium – higher prices to come?', www.neimagazine.com/opinion/opinionthe-future-of-uranium-higher-prices-to-come-4259437
[305] www.wise-uranium.org/dhap991.html
[306] www.bandepleteduranium.org/

However it is not certain that the plant will proceed[308] and more generally the development of Silex laser enrichment has been one step forward and two steps backwards.

Global Laser Enrichment (GLE) is a collaboration between GE, Hitachi, and Cameco. GLE has exclusive rights to commercially develop the SILEX laser isotope separation process technology under an agreement reached with Silex Systems Limited of Australia in 2006. GLE says it has "advanced the technology, successfully illustrating the concept through a test loop facility" in Wilmington, North Carolina. In 2012, GLE received the world's first license to operate a laser enrichment facility from the US Nuclear Regulatory Commission. In 2013, GLE entered into negotiations with the US Department of Energy for the potential establishment of a commercial uranium tails processing facility in Paducah, Kentucky. Negotiations continue.[309]

However GLE states: "Due to continued and forecasted pressure on the price of natural and light enriched uranium globally, in July 2014, GLE announced plans to pace continued development of the technology in line with current and future market realities."[310]

GLE announced in July 2014 it would cease funding laser uranium enrichment development projects at Lucas Heights in Sydney, and put the main project facility near Oak Ridge in Tennessee in "cold storage". Activities at Oak Ridge and Lucas Heights were to be consolidated into the Wilmington, North Carolina Test Loop facility. Silex Systems said the announcement was "unexpected" and GLE had already invested "hundreds of millions of dollars" in the project. Silex Systems said it has been advised that GLE continues to negotiate with the US Department of Energy on the opportunity for enrichment of depleted tails inventories in Paducah, Kentucky.[311]

Silex Systems CEO Michael Goldsworthy said in July 2014: "The global nuclear industry is still suffering the impacts of the Fukushima event and the shutdown of the entire Japanese nuclear power plant fleet in 2011. Demand for uranium has been slower to recover than expected and enrichment services are in significant oversupply."[312]

Laser enrichment has long raised proliferation concerns. A 1999 US State Department assessment stated that a laser enrichment facility "might be easier to build without detection and could be a more efficient producer of high enriched uranium for a nuclear weapons program."[313] The *Bulletin of the Atomic*

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[307] IAEA, July 2015, Nuclear Technology Review 2015, www.iaea.org/About/Policy/GC/GC59/GC59InfDocuments/English/gc59inf-2_en.pdf

[308] Steve Kidd, 4 July 2014, 'Uranium enrichment – what's happening today?', www.neimagazine.com/opinion/opinionuranium-enrichment-whats-happening-today-4311115/

[309] Global Laser Enrichment, https://nuclear.gepower.com/fuel-a-plant/products/gle.html [accessed 24 July 2015]

[310] Global Laser Enrichment, https://nuclear.gepower.com/fuel-a-plant/products/gle.html [accessed 24 July 2015]

[311] Giles Parkinson, 28 July 2014, 'Silex tumbles after solar-nuclear switch hits market roadblock', http://reneweconomy.com.au/2014/silex-tumbles-after-solar-nuclear-switch-hits-market-roadblock-51041
Silex Systems, 24 July 2014, 'GLE Restructures to Align with Adverse Market Conditions', http://asxcomnewspdfs.fairfaxmedia.com.au/2014/07/24/01535857-314409088.pdf

[312] Giles Parkinson, 28 July 2014, 'Silex tumbles after solar-nuclear switch hits market roadblock', http://reneweconomy.com.au/2014/silex-tumbles-after-solar-nuclear-switch-hits-market-roadblock-51041
Silex Systems, 24 July 2014, 'GLE Restructures to Align with Adverse Market Conditions', http://asxcomnewspdfs.fairfaxmedia.com.au/2014/07/24/01535857-314409088.pdf

[313] Michael Richardson, 6 Aug 2012, 'Uranium on the laser's edge', www.canberratimes.com.au/opinion/uranium-on-the-lasers-edge-20120805-23nko.html
See also:

Scientists noted in January 2014 that laser enrichment "promises to provide a route to uranium enrichment that is less expensive and harder-to-constrain than the centrifuge enrichment pursued by Iran and North Korea."[314]

Fuel fabrication

The IAEA 'Nuclear Technology Review 2015' states:[315]
"The current annual demand for light water reactor (LWR) fuel fabrication services remained at about 7000 t of enriched uranium in fuel assemblies, but is expected to increase to about 8000 t U per year by 2015. PHWR requirements accounted for 3000 t U per year. There are now several competing suppliers for most fuel types. Total global fuel fabrication capacity remained at about 13 500 t U per year (enriched uranium) for LWR fuel and about 4000 t U per year (natural uranium) for PHWR fuel."

Thus total capacity (17,500 tU) far exceeds demand (10,000−11,000 tU).

Reprocessing

Whereas conversion, enrichment and fuel fabrication are necessary stages of the nuclear power fuel cycle (excepting natural uranium fuelled reactors), reprocessing is not essential and is best treated separately.

The Switkowski Review[316] stated:
The complexity of reprocessing plants involving remote handling of highly radioactive and corrosive materials requires expensive facilities and many highly trained staff. ... The only recently constructed commercial scale reprocessing plant (Rokkasho) is estimated to have cost approximately US$18 billion. Reprocessing in Australia seems unlikely to be commercially attractive, unless the value of the recovered nuclear fuel increases significantly."

The Switkowski Review's comments on reprocessing still hold: it is an economic non-starter, all the more so given the capital costs − for example the World Nuclear Association states that the cost of Japan's Rokkasho reprocessing plant is JPY 2.4 trillion (US$20 billion).[317] Rokkasho also illustrates the long lead times often associated with complex technology. An application for permission to construct a reprocessing plant was first lodged in 1984. Currently, operation is not expected to commence until March 2016 with full capacity reached in 2019 − 35 years after the initial application.[318]

Jack Boureston and Charles D. Ferguson, March/April 2005, 'Laser enrichment: Separation anxiety', Bulletin of the Atomic Scientists, vol. 61, no. 2, pp.14-18, www.thebulletin.org/article.php?art_ofn=ma05boureston
ABC, 1 August 2013, 'Nuclear enrichment revolution meets weapon fears', www.abc.net.au/7.30/content/2013/s3816411.htm
'Briefing: Security fears over laser-enriched uranium', www.newscientist.com/article/dn20819-briefing-security-fears-over-laserenriched-uraniumhtml
William Broad, 21 Aug 2011, 'Laser advances in nuclear fuel stir terror fear', www.nytimes.com/2011/08/21/science/earth/21laser.html?_r=2&partner=rss&emc=rss&src=ig
Craig McMurtrie, 13 April 2010, 'Australian laser 'threatens nuclear security'', www.abc.net.au/news/stories/2010/04/13/2870904.htm
[314] Lawrence M. Krauss et al., 13 Jan 2014, 'Five minutes is too close', http://thebulletin.org/five-minutes-too-close
[315] IAEA, July 2015, Nuclear Technology Review 2015, www.iaea.org/About/Policy/GC/GC59/GC59InfDocuments/English/gc59inf-2_en.pdf
[316] Switkowski Review, 2006, Uranium Mining, Processing and Nuclear Energy Review, http://pandora.nla.gov.au/pan/66043/20070301-0000/www.pmc.gov.au/umpner/docs/nuclear_report.pdf
[317] www.world-nuclear.org/info/Country-Profiles/Countries-G-N/Japan--Nuclear-Fuel-Cycle/
[318] www.world-nuclear.org/info/Country-Profiles/Countries-G-N/Japan--Nuclear-Fuel-Cycle/

Reprocessing provides a direct pathway to fissile material for nuclear weapons (i.e. plutonium). That would warrant serious consideration but is a moot point since (conventional) reprocessing in Australia is an economic non-starter and has very few if any proponents.

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 (Sellafield) and France (La Hague). There are smaller plants in India, Russia and Japan. As mentioned, Japan plans to begin large-scale reprocessing at the Rokkasho plant. (In addition, a number of countries have military reprocessing plants.)

To date, around 80,000 tonnes of spent fuel from power reactors has been reprocessed, of the approximately 280,000 tonnes of spent fuel produced.[319]

Proponents of reprocessing give the following four justifications:

1. Reducing the volume and facilitating the management of high level radioactive waste. However reprocessing does nothing to reduce radioactivity or toxicity, while the overall waste volume, including low and intermediate level waste, is increased. Former World Nuclear Association executive Steve Kidd describes reprocessing as "environmentally dirty".[320]

2. 'Recycling' uranium to reduce reliance on natural reserves. However, only an improbably large expansion of nuclear power would result in any problems with uranium supply this century. The IAEA's 'Nuclear Technology Review 2015' states that at the 2013 rate of consumption, the lifetime of the 5.9 Mt U estimated total resources economically viable at current market prices would be 84 years. [321]

Furthermore, most uranium separated from spent fuel at reprocessing plants is not reused. It is "mostly stockpiled" according to the World Nuclear Association.[322] It contains isotopes such as uranium-232 which complicate its use as a reactor fuel. The IAEA's 'Nuclear Technology Review 2015' states that currently about 100 t of reprocessed uranium per year are produced in Russia for AREVA, and AREVA itself converts about 80 t of heavy metal of reprocessed uranium into fuel per year for reactors in France, using a plant in Romans, France.[323]

3. Separating plutonium for use as nuclear fuel. There is very little demand for plutonium as a nuclear fuel. It is used in 'MOX' reactor fuel (mixed uranium-plutonium oxide), which accounts for about 5% of worldwide nuclear fuel[324], and possibly in a small number of fast neutron reactors.

4. Using plutonium as a fuel so that it can no longer be used in nuclear weapons. However, reactors which can use plutonium as fuel also *produce* plutonium. Moreover, since there is so little demand for plutonium as a reactor fuel, stockpiles of separated plutonium have steadily increased and now amount

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[319] Steve Kidd, 4 Oct 2011, 'Reprocessing used fuel – what is the future?', www.neimagazine.com/opinion/opinionreprocessing-used-fuel-what-is-the-future/
[320] Steve Kidd, 11 May 2004, "Achilles heel or own goal?", Nuclear Engineering International, http://web.archive.org/web/20050104135624/http://www.neimagazine.com/story.asp?sectionCode=147&storyCode=2023239
[321] IAEA, July 2015, Nuclear Technology Review 2015, www.iaea.org/About/Policy/GC/GC59/GC59InfDocuments/English/gc59inf-2_en.pdf
[322] World Nuclear Association, 8 Oct 2014, 'Supply of Uranium', www.world-nuclear.org/info/Nuclear-Fuel-Cycle/Uranium-Resources/Supply-of-Uranium/
[323] IAEA, July 2015, Nuclear Technology Review 2015, www.iaea.org/About/Policy/GC/GC59/GC59InfDocuments/English/gc59inf-2_en.pdf
[324] World Nuclear Association, Dec 2014, 'Mixed Oxide (MOX) Fuel', www.world-nuclear.org/info/Nuclear-Fuel-Cycle/Fuel-Recycling/Mixed-Oxide-Fuel-MOX/

to about 260 tonnes[325] (enough for 26,000 nuclear weapons). Reprocessing has clearly worsened rather than reduced proliferation risks. Addressing the problem of growing stockpiles of separated plutonium could hardly be simpler – it only requires that reprocessing be slowed, suspended, or stopped altogether.

The main reason reprocessing proceeds is that reprocessing plants act as long-term, de facto storage facilities for spent nuclear fuel. Unfortunately this sets up a series of events which has been likened to the old woman who swallowed a fly – every solution is worse than the problem it was supposed to solve:
1. The perceived need to do something about growing spent fuel stockpiles at reactor sites (not least to maintain or obtain reactor operating licences), coupled with 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.
2. Eventually the spent fuel must be reprocessed, which brings with it proliferation, public health and environmental risks.
3. Reprocessing has led to a large and growing stockpile of separated plutonium, which is an unacceptable and unnecessary proliferation risk.
4. Reprocessing creates the 'need' to develop mixed uranium-plutonium fuel (MOX) or fast neutron reactors to make use of the separated plutonium.
5. 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/diversion leading to the production of nuclear weapons or 'dirty bombs'.

Fuel leasing

Fuel 'leasing' proposals for South Australia could involve:
- uranium export, and the subsequent import and storage or disposal of high-level nuclear waste arising from the use of that uranium in power reactors overseas; or
- comprehensive 'front end' processes (uranium mining, conversion into uranium hexafluoride, enrichment, fuel fabrication) and 'back end' management of spent fuel (reprocessing and re-export, storage and/or disposal).

Among other problems and obstacles, the simpler of those options − uranium export and spent fuel take-back − would likely be unacceptable to at least some of Australia's major uranium customers. BHP Billiton said in its submission to the Switkowski Review said that its major customers "have choices" about where to acquire uranium and "these utilities generally regard their spent fuel as an asset − a resource for future reprocessing to produce more fuel input."[326]

A comprehensive leasing scheme would involve entry into several markets which are already oversupplied (conversion, enrichment, fuel fabrication) and which in some cases (esp. enrichment) are technically challenging with high entry barriers and high entry costs. The improbability of entry into those markets is clearly spelt out in the 2006 Switkowski Review[327] and BHP Billiton's submission[328] to the Switkowski Review − and they are as improbable now as they were in 2006.

BHP Billiton's submission stated:[329]
"BHP Billiton believes that there is neither a commercial nor a non-proliferation case for it to become involved in front-end processing or for mandating the development of fuel leasing services in Australia. ... We do not believe that conversion and enrichment would be commercially viable in Australia. Nor do

[325] International Panel on Fissile Materials, www.fissilematerials.org
[326] http://web.archive.org/web/20070830182528/www.pmc.gov.au/umpner/submissions/223_sub_umpner.pdf
[327] http://pandora.nla.gov.au/pan/66043/20070301-0000/www.pmc.gov.au/umpner/docs/nuclear_report.pdf
[328] http://web.archive.org/web/20070830182528/www.pmc.gov.au/umpner/submissions/223_sub_umpner.pdf
[329] http://web.archive.org/web/20070830182528/www.pmc.gov.au/umpner/submissions/223_sub_umpner.pdf

we believe any government imposed requirement to lease fuel, as distinct from acquiring uranium would be acceptable to its major customers, all of whom have alternative choices about where to acquire their U3O8 ... The economics of any Australian conversion, enrichment or fabrication do not look positive, either individually or collectively. ... There is no evidence that a change to current Australian Government policies to facilitate domestic enrichment, fuel leasing and high level waste disposal would lead to significant economic opportunities or reduce proliferation risks in the foreseeable future."

BHP Billiton's submission further stated:[330]
"BHP Billiton has no intention to use the [Olympic Dam] mine as a basis to begin providing fuel leasing, conversion, enrichment, nuclear power or national or international waste disposal/storage services. ... [U]tilities typically acquire U3O8 and then contract directly with established conversion, enrichment and fuel fabrication service suppliers to meet their specific technical specifications for long periods and often spread supply agreements across a number of suppliers. Customers value this flexibility and choice. ... There is little evidence of a preference for purchasing a "bundled" supply of U3O8, conversion, enrichment and fuel fabrication services and no established market for fuel leasing."

BHP Billiton was particularly critical of proposals that would require the company to require uranium customers to enter into fuel leasing arrangements:[331]
"There is no evidence that a change to current Australian Government policies to facilitate domestic enrichment, fuel leasing and high level waste disposal would lead to significant economic opportunities or reduce proliferation risks in the foreseeable future. ... It would also put at risk our reputation with customers of being a reliable supplier of uranium concentrates and our ability to enter into the long term supply arrangements that underpin expansion of uranium mining. Noting that a nuclear fuel leasing industry − if permitted by the regulatory framework − is most unlikely to be commercially viable, BHP Billiton would strongly oppose any policies to artificially support the premature development of such an industry by requiring BHP Billiton's customers to use Australian conversion, enrichment or fabrication services − or to quarantine reserves to underpin such a domestic capacity in the future. It would put customer relations and the investments those underpin at risk."

SAFEGUARDS AND SECURITY

SAFEGUARDS

2.12 What safeguards issues are created by the further participation in South Australia in activities (such as the production of uranium oxide, conversion, enrichment, fuel fabrication or reprocessing) necessary for uranium to be used as a fuel in electricity generation? Can those implications be addressed? If so, by what means? Further, would the possession of those technical capabilities give rise to strategic and policy issues for Australia? If so, what are those issues and how could they be addressed?

Those questions are addressed under the following subheadings:
- Two reasons why safeguards are vital: uranium exports, and Australia's compromised position regarding nuclear weapons
- The limitations of safeguards − summary
- Australia's uranium export policy / customer countries
- Provisions in bilateral agreements − enrichment and reprocessing
- Not all facilities processing AONM are subject to IAEA inspections
- Australia's uranium exports are shrouded in secrecy

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[330] http://web.archive.org/web/20070830182528/www.pmc.gov.au/umpner/submissions/223_sub_umpner.pdf
[331] http://web.archive.org/web/20070830182528/www.pmc.gov.au/umpner/submissions/223_sub_umpner.pdf

- Safeguards and Australia's uranium exports − proposed uranium sales to India
- Safeguards and Australia's uranium exports − uranium sales to Russia
- The Australian Safeguards and Non-Proliferation Office (ASNO)
- The *realpolitik* of Australian safeguards policy
- New reactors types − proliferation-resistant?
- Misinformation promulgated by nuclear advocates

Two reasons why safeguards are vital: uranium exports, and Australia's compromised position regarding nuclear weapons

The issues of safeguards is highly relevant to Australia's uranium exports.

As mentioned previously ('Enrichment and proliferation), Australia's active support for and reliance on (US) nuclear weapons is well-known and Australia is thus regarded as untrustworthy regarding nuclear weapons proliferation. As former IAEA Director-General Mohamed El Baradei noted:
"Why, some ask, should the nuclear-weapon States be trusted, but not others − and who is qualified to make that judgment? Why, others ask, is it okay for some to live under a nuclear threat, but not others, who continue to be protected by a 'nuclear umbrella'?"[332]

Australia's historical efforts to lower the lead time for weapons production are well documented. For example, Prime Minister John Gorton undoubtedly had military ambitions for a nuclear power reactor he wanted to have constructed in the late 1960s at Jervis Bay. He later said: "We were interested in this thing because it could provide electricity to everybody and it could, if you decided later on, it could make an atomic bomb."[333] Since the mid-1980s (when then foreign minister Bill Hayden wanted Australia to develop a "pre-nuclear weapons capability"[334]), there has been very little or no interest in developing weapons or developing the capacity to produce nuclear weapons. Thus, for example, Australia was quick to sign an Additional Protocol allowing the IAEA greater safeguards inspection rights.

What might eventuate if problems or uncertainty emerged with the US nuclear alliance? Given the bipartisan support for and reliance on nuclear weapons, it is possible that Australia might take steps towards developing a nuclear weapons capability through with the development of enrichment technology, or reactors and reprocessing, etc. The question of Australia revisiting the option of an Australian nuclear weapons capacity has been raised by several analysts in recent years.[335]

Australian efforts to move towards a weapons capability − either deliberately or as an unavoidable consequence of the pursuit of a civil nuclear program − would encourage other regional countries (e.g Indonesia) to do likewise.

The limitations of safeguards − summary

There are many problems and limitations with the international safeguards system.[336] In articles and speeches during his tenure as IAEA Director General from 1997− 2009, Dr. Mohamed El Baradei said

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[332] http://web.archive.org/web/20070829214153/http://www.wagingpeace.org/articles/2007/05/24_ElBaradei_Preventing_Nuclear_Catastrophe.htm
[333] Pilita Clark, 1 Jan 1999, 'PM's Story: Very much alive... and unfazed', *Sydney Morning Herald*.
[334] Bill Hayden, 1996, Hayden: An Autobiography, Sydney: Angus and Robertson, pp.422-423.
[335] Nautilus Institute, n.d., 'Australian nuclear proliferation – contemporary', http://nautilus.org/projects/by-name/aus-indo/aust-ind-nuclear1/australia-nuclear-proliferation/aust-prolif-now/
[336] For information on safeguards see the papers listed at www.foe.org.au/anti-nuclear/links#safeguards

that the Agency's basic rights of inspection are "fairly limited", that the safeguards system suffers from "vulnerabilities" and "clearly needs reinforcement", that efforts to improve the system have been "half-hearted", and that the safeguards system operates on a "shoestring budget ... comparable to that of a local police department".

Problems with safeguards include:

1. Chronic under-resourcing.[337] El Baradei told the IAEA Board of Governors in 2009: "I would be misleading world public opinion to create an impression that we are doing what we are supposed to do, when we know that we don't have the money to do it."[338] Little has changed since 2009. Meanwhile, the scale of the safeguards challenge is ever-increasing as new facilities are built and materials stockpiles grow.

2. Issues relating to national sovereignty and commercial confidentiality adversely impact on safeguards.

3. The inevitability of accounting discrepancies. Nuclear accounting discrepancies are commonplace and inevitable due to the difficulty of precisely measuring nuclear materials. The accounting discrepancies are known as Material Unaccounted For (MUF). There have been incidents of large-scale MUF in Australia's uranium customer countries such as the UK and Japan.[339]

4. Incorrect/outdated assumptions about the amount of fissile material required to build a weapon.

5. The fact that the IAEA has no mandate to prevent the misuse of civil nuclear facilities and materials − at best it can detect misuse/diversion and refer the problem to the UN Security Council. As the IAEA states: "It is clear that no international safeguards system can physically prevent diversion or the setting up of an undeclared or clandestine nuclear programme."[340] Numerous examples illustrate how difficult and protracted the resolution (or attempted resolution) of such issues can be, e.g. North Korea, Iran, Iraq in the 1970s and again in the early 1990s. Countries that have breached their safeguards obligations can simply withdraw from the NPT and pursue a weapons program, as North Korea has done.

6. Safeguards are shrouded in secrecy − to give one example, the IAEA used to publish aggregate data on the number of inspections in India, Israel and Pakistan, but even that nearly worthless information is no longer publicly available.

7. There are precedents for the complete breakdown of nuclear safeguards in the context of political and military conflict − examples include Iraq, Yugoslavia and several African countries.

8. Currently, IAEA safeguards only begin at the stage of uranium enrichment. Application of IAEA safeguards should be extended to fully apply to mined uranium ores, to refined uranium oxides, to uranium hexafluoride gas, and to uranium conversion facilities, as well as enrichment and subsequent stages of the nuclear fuel cycle. The Joint Standing Committe on Treaties (JSCT) recommended in 2008 that "the Australian Government lobbies the IAEA and the five declared nuclear weapons states under

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[337] See section 6 in: 'The Nuclear Safeguards System: An Illusion of Protection', 2010, www.choosenuclearfree.net/safeguards/

[338] Mohamed El Baradei, 16 June 2009, 'Director General's Intervention on Budget at IAEA Board of Governors', www.iaea.org/newscenter/statements/director-generals-intervention-budget-iaea-board-governors

[339] See section 4 in: 'The Nuclear Safeguards System: An Illusion of Protection', 2010, www.choosenuclearfree.net/safeguards/

[340] IAEA, 1993, Against the Spread of Nuclear Weapons: IAEA Safeguards in the 1990s.

the NPT to make the safeguarding of all conversion facilities mandatory."[341] However the Australian Government rejected the recommendation in its 2009 response to the JSCT report.[342]

9. There is no resolution in sight to some of the most fundamental problems with safeguards such as countries invoking their right to pull out of the Nuclear Non-Proliferation Treaty (NPT) and developing a weapons capability as North Korea has done. More generally, responses to suspected non-compliance with safeguards agreements have been highly variable, ranging from inaction to economic sanctions to UN Security Council-mandated decommissioning programmes. Some states prefer to take matters into their own hands: Israel bombed and destroyed a nuclear reactor in Iraq in 1981, the US bombed and destroyed a reactor in Iraq in 1991 and Israel bombed and destroyed a suspected reactor site in Syria in 2007.

In 1982, Mike Rann identified the core problem: "Again and again, it has been demonstrated here and overseas that when problems over safeguards prove difficult, commercial considerations will come first."[343]

For more information on the limitations of safeguards see:

Medical Association for the Prevention of War and Australian Conservation Foundation, 2006, "An Illusion of Protection: The Unavoidable Limitations of Safeguards", www.mapw.org.au/download/illusion-protection-acf-mapw-2006

Henry Sokolski (ed.), Feb 2008, "Falling Behind: International Scrutiny of the Peaceful Atom", www.strategicstudiesinstitute.army.mil/pubs/display.cfm?pubID=841

Alan J. Kuperman, David Sokolow, and Edwin S. Lyman, March 18, 2014, 'Can the IAEA Safeguard Fuel-Cycle Facilities?', Nuclear Proliferation Prevention Project, LBJ School of Public Affairs, University of Texas at Austin (www.NPPP.org), http://blogs.utexas.edu/nppp/files/2014/03/NPPP-working-paper-2-2014-Mar-18.pdf

Looking beyond Iran and North Korea for Safeguarding the Foundations of Nuclear Nonproliferation, former IAEA Safeguards Director Pierre Goldschmidt, Nov 15, 2011, www.npolicy.org/article.php?aid=1115&tid=4

Building Support for the Agencys Safeguards Mission, Henry Sokolski, Nov 03, 2010, Nonproliferation Policy Education Centre, www.npolicy.org/article.php?aid=50&rtid=6

Non-proliferation Policy Education Centre www.npolicy.org and see in particular the section on the non-proliferation regime www.npolicy.org/topics.php?page=0&tid=4

Nuclear Power Joint Fact Finding Dialogue, June 2007, https://www.keystone.org/policy-initiatives-center-for-science-a-public-policy/energy/nuclear-power-joint-fact-finding.html

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[341] Joint Standing Committee on Treaties, 2008, 'Report 94: Review into Treaties tabled on 14 May 2008', www.aph.gov.au/parliamentary_business/committees/house_of_representatives_committees?url=jsct/14may2008/report1/fullreport.pdf

[342] Australian Government, 2009, 'Government Response to Report 94 of the Joint Standing Committee on Treaties: Australia-Russia Nuclear Cooperation Agreement'

[343] Mike Rann, March 1982, 'Uranium: Play It Safe'.

Value-subtracting: Form vs. substance in Australian uranium safeguard policy, Richard Leaver, Austral Special Report 09-08S, 11 December 2009, Nautilus Institute, http://nautilus.wpengine.netdna-cdn.com/wp-content/uploads/2012/02/leaver-safeguards.pdf

Nuclear Safeguards: some Canadian questions about Australian policy, Richard Leaver, Austral Policy Forum 09-5A, 23 February 2009, http://nautilus.org/apsnet/nuclear-safeguards-some-canadian-questions-about-australian-policy/

The Nuclear Safeguards System: An Illusion of Protection, 2010, www.choosenuclearfree.net/safeguards/

Australia's uranium export policy / customer countries

Here brief comment is made about the choice of uranium customer countries. In 1998, the then Director-General of the Australian Safeguards and Non-proliferation office (ASNO) said: "One of the features of Australian policy ... is very careful selection of our treaty partners. We have concluded bilateral arrangements only with countries whose credentials are impeccable in this area."[344]

That was not true at the time (e.g. sales to declared nuclear weapons states that pay scant regard to their NPT obligations) and it is certainly not true now.

Recommendation 33: The Royal Commission should recommend that state and federal governments no longer permit uranium sales to:

- repressive, secretive countries (e.g. China and Russia − albeit the case that sales to Russia have been suspended)
- nuclear weapons states that are not fulfilling their disarmament obligations under the Nuclear Non-Proliferation Treaty (US, Russia, China, France, UK)
- countries that have not ratified the Comprehensive Test Ban Treaty (China, USA, India)
- countries with a history of weapons-related research based on their civil nuclear programs (South Korea and Taiwan).

Provisions in bilateral agreements − enrichment and reprocessing

In addition to IAEA safeguards, countries purchasing Australian uranium must sign a bilateral agreement. However there are no Australian inspections of nuclear materials stockpiles or facilities using Australian Obligated Nuclear Materials (AONM − primarily uranium and its by-products such as plutonium) – Australia is entirely reliant on the inadequate and underfunded inspection system of the IAEA.

The most important provisions in bilateral agreements are for prior Australian consent before Australian nuclear material is transferred to a third party, enriched beyond 20% uranium-235, or reprocessed. However no Australian government has ever refused permission to separate plutonium from spent fuel via reprocessing (and there has never been a request to enrich beyond 20% U-235). Even when reprocessing leads to the stockpiling of plutonium (which can be used directly in nuclear weapons), ongoing or 'programmatic' permission has been granted by Australian governments. Hence there are stockpiles of Australian-obligated separated plutonium in Japan and in some European countries.

[344] John Carlson, 1998, http://web.archive.org/web/20040217071924/http://www.aph.gov.au/hansard/joint/commttee/j2022.pdf, p.15

Japan, a major customer of Australian uranium, has a nuclear 'threshold' or 'breakout' capability − it could produce nuclear weapons within months of a decision to do so, relying heavily on facilities, materials and expertise from its civil nuclear program. An obvious source of fissile material for a weapons program in Japan would be its stockpile of plutonium − including Australian-obligated plutonium. In April 2002, the then leader of Japan's Liberal Party, Ichiro Ozawa, said Japan should consider building nuclear weapons to counter China and suggested a source of fissile material: "It would be so easy for us to produce nuclear warheads; we have plutonium at nuclear power plants in Japan, enough to make several thousand such warheads."

Japan's plutonium program increases regional tensions and proliferation risks. Diplomatic cables in 1993 and 1994 from US Ambassadors in Tokyo describe Japan's accumulation of plutonium as "massive" and questioned the rationale for the stockpiling of so much plutonium since it appeared to be economically unjustified.[345] A March 1993 diplomatic cable from US Ambassador Armacost in Tokyo to Secretary of State Warren Christopher, obtained under the US Freedom of Information Act, posed these questions: "Can Japan expect that if it embarks on a massive plutonium recycling program that Korea and other nations would not press ahead with reprocessing programs? Would not the perception of Japan's being awash in plutonium and possessing leading edge rocket technology create anxiety in the region?"[346]

Japan's plutonium stockpiling and reprocessing plans continue to cause regional concern − for example China has recently voiced concern.[347] Moreover it continues to complicate efforts to prevent other regional countries (esp. South Korea) from going down the same plutonium/reprocessing path.

Despite this, Australia continues to provide open-ended ('programmatic') approval for Japan to separate Australian-obligated plutonium. The government could and should prohibit the stockpiling of Australian-obligated plutonium. At the very least, the government should revert to the previous Australian policy of requiring approval for plutonium separation / reprocessing on a case-by-case basis.

It is frequently claimed that the "strict" or "stringent" conditions placed on AONM encourage a strengthening of non-proliferation measures generally. However, by permitting the stockpiling of plutonium the Australian government is not 'raising the bar' but is setting a poor example and encouraging other uranium exporters to adopt or persist with equally irresponsible policies. While the Australian government does not have the authority to prohibit stockpiling, it does have the authority to permit transfers and reprocessing of AONM and could therefore put an end to the stockpiling of Australian-obligated plutonium.

Recommendation 34: The Royal Commission should recommend that state and federal governments prohibit high enrichment of Australian uranium and prohibit the separation and stockpiling of Australian-obligated plutonium.

Not all facilities processing AONM are subject to IAEA inspections

Australia allows the processing of AONM in facilities which are not covered by IAEA safeguards at all. While AONM is meant to be subject to IAEA safeguards from the enrichment stage onwards, ASNO is willing to make exceptions.

For example ASNO has recommended that the Australian government agree to the processing of Australian uranium in unsafeguarded enrichment plants in Russia and the recommendation was readily

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[345] http://web.archive.org/web/20081114064230/http://archive.greenpeace.org/pressreleases/nuctrans/1999sep1.html
[346] http://web.archive.org/web/20081114064230/http://archive.greenpeace.org/pressreleases/nuctrans/1999sep1.html
[347] Jonathan Tirone and Jacob Adelman, 24 March 2014, 'Japan's Plutonium Plans Stoke China Tensions on A-Bomb Risk', www.bloomberg.com/news/2014-03-23/japan-s-plutonium-potential-stokes-china-tensions-on-a-bomb-risk.html

accepted by the federal government. ASNO states: "Russia does not propose to place these enrichment facilities on its Eligible Facilities List because the facilities were never designed for the application of safeguards and could not be readily adapted for safeguards purposes."[348]

The enrichment facilities would not require any adaptation whatsoever. Russia simply needs to permit the application of safeguards and the IAEA could then adopt safeguards measures such as inspections, the use of video monitoring etc.

Recommendation 36: The Royal Commission should recommend that state and federal governments prohibit the processing of Australian Obligated Nuclear Materials in facilities beyond the scope of IAEA safeguards.

Australia's uranium exports are shrouded in secrecy

Nuclear transfers and developments demand the highest level of transparency, however this is often not the case. Some example of unjustified secrecy include the refusal of successive Australian governments to publicly release:

1. Country-by-country information on the separation and stockpiling of Australian-obligated plutonium.

2. 'Administrative Arrangements' which contain vital information about the safeguards arrangements required by Australia.

3. Information on nuclear accounting discrepancies (Material Unaccounted For) including the volumes of nuclear materials, the countries involved, and the reasons given to explain these accounting discrepancies. The JSCT recommended that: "Further consideration is given to the justification for secrecy of Material Unaccounted For'."[349] There is no legitimate justification for the secrecy surrounding MUF. ASNO has done no better than to cite commercial confidentiality.[350] All MUF information, past, present and future, should be reported publicly and this should be done on a country-by-country and facility-by-facility basis. Some other countries (e.g. Japan) release MUF data and thus Australia's secrecy clearly fails to meet best practice.

4. The quantities of AONM held in each country are confidential. ASNO states: "The actual quantities of AONM held in each country, and accounted for by that country pursuant to the relevant agreement with Australia, are considered by ASNO's counterparts to be confidential information."[351]

Recommendation 37: The Royal Commission should recommend public release of country-by-country information on the separation and stockpiling of Australian-obligated plutonium; all current and future 'Administrative Arrangements' pertaining to uranium exports; detailed information on nuclear accounting discrepancies including the volumes of nuclear materials, the countries involved, and the

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[348] ASNO, 2008, Answer 'DD' in response to Questions on Notice to ASNO, Question 20, Output 1.1.10, October 2008 session of Senate Estimates, questions by Senator Ludlam.

[349] Joint Standing Committee on Treaties, 2008, 'Report 94: Review into Treaties tabled on 14 May 2008', List of Recommendations, www.aph.gov.au/parliamentary_business/committees/house_of_representatives_committees?url=jsct/14may2008/report1/fullreport.pdf

[350] www.aph.gov.au/parliamentary_business/committees/house_of_representatives_committees?url=jsct/14may2008/subs/sub22_1.pdf

[351] ASNO − Australian Safeguards and Non-proliferation Office, 2001-02, Annual Report, www.asno.dfat.gov.au/annual_report_0102/asno_annual_report_2001_2002.pdf

reasons given to explain accounting discrepancies; and the quantities of Australian Obligated Nuclear Materials held in each country.

Safeguards and Australia's uranium exports − proposed uranium sales to India

The Australian government is in the process of further compromising the safeguards system by pursuing a nuclear cooperation agreement with India that weakens safeguards standards in many respects. The agreement is currently before the Australian Parliament's Joint Standing Committee on Treaties (JSCT). In its current form, the agreement has been strongly opposed by, among others, a former Director-General of the Australian Safeguards and Non-Proliferation Office (John Carlson), a former Chair of the Board of Governors of the International Atomic Energy Agency (Ronald Walker), a former Assistant Director of the US Arms Control and Disarmament Agency (Prof. Lawrence Scheinman), and an Australian nuclear arms control expert (Crispin Rovere).[352]

John Carlson, who headed Australia's safeguards office for 21 years, argues that the agreement with India "represents a serious weakening of Australia's ... safeguards conditions" and that weaknesses in the agreement "mean Australian material could be used in support of India's nuclear weapon program."[353]

If the uranium agreement is approved, there will be sustained pressure for Australia to apply equally inadequate standards to other countries. As John Carlson noted in a submission to JSCT: "If the Government does compromise Australia's safeguards conditions, inevitably this will lead to other agreement partners asking for similar treatment."[354]

Moreover, other nuclear and uranium exporting countries will follow Australia's lead and weaken their safeguards requirements. This disturbing and cascading retreat from responsibility would further compromise non-proliferation objectives and mechanisms.

Recommendation 38: The Royal Commission should recommend that state and federal governments do not permit uranium sales to countries that have not signed the Non-Proliferation Treaty or the Comprehensive Test Ban Treaty and are actively expanding their nuclear weapons arsenals (e.g. India).

Safeguards and Australia's uranium exports − uranium sales to Russia

Submissions to the JSCT India inquiry by John Carlson and some others argued that Australia's safeguards requirements were robust other than the seriously defective Australia−India Nuclear Cooperation Agreement.

Those arguments do not stand up to scrutiny, and there is no clearer illustration of profound problems than the Australia−Russia Nuclear Cooperation Agreement.[355] The JSCT rejected[356] the agreement to sell uranium to Russia when it learnt that IAEA safeguards inspections in Russia are nearly non-existent. Among other recommendations the JSCT said it is "essential that actual physical inspection by the IAEA occurs at any Russian sites that may handle" Australian uranium and that uranium exports "should be contingent upon such inspections being carried out." The major parties in Canberra rejected the

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[352] See their submissions to the JSCT: www.aph.gov.au/Parliamentary_Business/Committees/Joint/Treaties/28_October_2014/Submissions

[353] www.aph.gov.au/DocumentStore.ashx?id=35fb7f72-904c-4d44-b387-f34e4afb77f9&subId=301365

[354] www.aph.gov.au/DocumentStore.ashx?id=79a1a29e-5691-4299-8923-06e633780d4b&subId=301365

[355] www.foe.org.au/anti-nuclear/issues/oz/u/cc#russia

[356] www.aph.gov.au/Parliamentary_Business/Committees/House_of_Representatives_Committees?url=/jsct/14may2008/report1/fullreport.pdf

recommendation − they were prepared to allow uranium sales to Russia despite being well aware that IAEA safeguards inspections are very nearly non-existent.

ASNO failed to advise the JSCT that safeguards inspections in Russia are very nearly non-existent − until that information was provided to the JSCT by an NGO. In other words, ASNO misled the JSCT and thereby misled Parliament. Further, ASNO's submission to the JSCT inquiry into uranium sales to Russia said that Australia exports uranium under "strict non-proliferation conditions." The reality of near-zero safeguards inspections cannot be squared with the claimed of strict conditions.

Likewise, ASNO's 'Regulation Impact Statement' stated: "These agreements establish strict safeguards and control measures to ensure that exported uranium, nuclear equipment, or technology, are used solely for peaceful, non-military purposes." That claim cannot be squared with the reality of nearly non-existent safeguards inspections in Russia.

Recommendation 39: The Royal Commission should investigate the deficiencies in the process leading to the approval of uranium sales to Russia, including statements made by the Australian Safeguards and Non-proliferation Office.

The Australian Safeguards and Non-Proliferation Office (ASNO)

A 2007 EnergyScience Coalition paper detailed many problems with ASNO. The paper concluded:[357]

"The authors of this paper believe there is a compelling case for major reform of ASNO as a matter of urgency. An alternative course of action would be for the Australian government to establish an independent public inquiry. Such an inquiry should have a broad mandate to review all aspects of ASNO's structure and function, should be adequately resourced, and should have powers similar to those of a Royal Commission to access witnesses, documents and other evidence.

"Such an inquiry should be carried out independently of ASNO. It should also be carried out independently of the Department of Foreign Affairs and Trade (DFAT), given that the current relationship between ASNO and DFAT is arguably one of the areas in need of review. DFAT has declined a request to review a paper detailing numerous inaccurate statements made by ASNO (letter to NGOs, 28 May 2007, available on request).

"Such an inquiry should address the competence and performance of ASNO; its scientific and technical expertise; whether its current management, organisation, structure and relationships best serve its mandate; any conflicts of interest; the implications of ASNO's structural connection to DFAT (whether it has sufficient independence or operates as a 'captured bureaucracy'); and options for reform including consideration of organisational models in other countries.

Since the 2007 paper was written, ASNO's performance has become even more problematic, e.g. misleading the JSCT regarding safeguards in Russia, e.g. ASNO's defence of the indefensible Australia−India Nuclear Cooperation Agreement.

Recommendation 40: The Royal Commission should recommend an independent public inquiry covering all aspects of the operation of the Australian Safeguards and Non-proliferation Office.

The following article summarises some of ASNO's failings:

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[357] EnergyScience Coalition, 2007, 'Who's Watching the Nuclear Watchdog - A Critique of the Australian Safeguards and Non-Proliferation Office', www.energyscience.org.au/BP19%20ASNO.pdf

Who's watching the nuclear watchdog?
Richard Broinowski and Tilman Ruff
Online Opinion
10 September 2007
www.onlineopinion.com.au/view.asp?article=6339
Australia has been poorly served by the Australian Safeguards and Non-Proliferation Office, the Commonwealth agency tasked with preventing nuclear proliferation dangers associated with Australia's uranium exports. Its failures are so numerous and significant that, along with other members of the EnergyScience Coalition, we have written a comprehensive critique of the Office and call on the federal government to establish an independent public inquiry.
The Safeguards Office makes the absurd claim that Australia only sells uranium to countries with "impeccable" non-proliferation credentials. In fact, Australia has uranium export agreements with nuclear weapon states (all of which are failing to fulfill their disarmament obligations under the Non-Proliferation Treaty) as well as with states with a history of covert nuclear weapons research based on their "civil" nuclear programs (such as South Korea and Taiwan).
The government also permits - and the Safeguards Office supports - uranium sales to countries (including the United States) which are blocking progress on the Comprehensive Test Ban Treaty and the proposed Fissile Material Cut-Off Treaty.
Now the government proposes allowing uranium sales to India, not even a signatory to the Non-Proliferation Treaty. This is a serious blow to the international non-proliferation regime yet has been met with silence from the Safeguards Office.
Last year's debate on uranium sales to China showed the Safeguards Office at its worst. In testimony to the Joint Standing Committee on Treaties, the Office did not know the number of nuclear facilities in China, nor how many or which of these would process uranium and its by-products. Nor did it know how the International Atomic Energy Agency (IAEA) selected nuclear facilities for inspection. The Safeguards Office was dismissive of China having the worst record of exports of proliferation-sensitive materials and know-how of any of the nuclear weapon states.
The Safeguards Office routinely misleads us when it asserts that nuclear safeguards "ensure" or "provide assurances" that Australian uranium will not contribute to weapons proliferation. These assurances contrast with the frankness of Dr Mohamed El Baradei, head of the IAEA, who acknowledges that the international safeguards system suffers from "vulnerabilities", not least because it runs on a "shoe string budget", and that efforts to improve the system have been "half-hearted".
The Safeguards Office claims that all nuclear materials derived from Australia's uranium exports are "fully accounted for". That claim is false. There are frequent accounting discrepancies involving Australia's nuclear exports. What the Safeguards Office means when it says that nuclear material is "fully accounted for" is that it has accepted all the explanations provided by uranium customer countries for accounting discrepancies, however fanciful those explanations may be. Secrecy is another feature of the Safeguards Office - it refuses to provide specific or even aggregate data on nuclear accounting discrepancies.
Perhaps the most misleading of the claims made by the Safeguards Office is its repeated assertion that nuclear power does not present a weapons proliferation risk. In fact, power reactors have been used directly in weapons programs. Some examples include India, which is reserving eight out of 22 power reactors for weapons production; the use of a power reactor in the United States to produce tritium, used to boost the yield of nuclear weapons; and North Korea's use of an "Experimental Power Reactor" to produce plutonium for weapons.
Nuclear power programs also indirectly facilitate weapons programs by providing a rationale for acquiring proliferative technologies such as research reactors, uranium enrichment plants and reprocessing plants.
The IAEA, the US Department of Energy and other authorities consider almost all plutonium to be weapons-usable, yet the Safeguards Office continues to claim that plutonium derived from power reactors is not suitable for weapons. This is not only wrong; it is dangerous.

The inevitable conclusion arising from our detailed critique of the Safeguards Office (posted at www.energyscience.org.au) is that, at best, it is ineffectual, providing an illusion that an independent agency is protecting the interests of the Australian people when it comes to the vital matter of preventing nuclear proliferation. At worst, the Safeguards Office serves the commercial interests of the nuclear industry and the political interests of those who promote it, and contributes more to the problem of nuclear weapons proliferation than to the solutions.
We call on the federal government to establish an independent public inquiry to review all aspects of the Safeguards Office - its performance; scientific and technical expertise; whether its current management, organisation and relationships best serve its mandate; any conflicts of interest; whether it has sufficient independence; and options for reform. The inquiry should be adequately resourced, and should have powers similar to those of a Royal Commission to access witnesses, documents and other evidence.

For more information on ASNO see:
www.foe.org.au/anti-nuclear/issues/oz/u/safeguards/asno

The *realpolitik* of Australian safeguards policy

It is sometimes claimed that Australia's safeguards requirements are the equal of or better than those applied by any other uranium-exporting country. However the IAEA is responsible for safeguards regardless of the origin of uranium supplies. And there are serious flaws with Australia's safeguards policies:

- Australia can claim little or no credit for the provisions of bilateral agreements given that key provisions have never been invoked (high enrichment), or, in the case of plutonium separation/stockpiling, permission has never been denied.
- In some cases Australia allows AONM to be processed in non-safeguards-eligible facilities.
- Australia allows uranium sales to nuclear weapons states which show little inclination to abide by their NPT disarmament obligations; states with a history of weapons-related research based on their civil nuclear programs; states blocking progress on the Comprehensive Test Ban Treaty and the proposed Fissile Material Cut-Off Treaty; and to undemocratic, repressive, secretive states with extensive and documented human rights abuses.
- Uranium exports are shrouded in secrecy at many levels.
- ASNO is in great need of radical reform, or abolition and replacement with a more credible safeguards agency.

Australia could use its status as the world's largest holder of uranium reserves to leverage non-proliferation and disarmament outcomes. Australia could, for example, have promoted the adoption of 'Additional Protocols', strengthened safeguards agreements which provide the IAEA with greater authority to inspect suspected diversion of nuclear materials. Australia could have led by insisting that all of Australia's uranium customer countries must have an Additional Protocol in place. Indeed Australia does now require Additional Protocols of all customer countries − but that policy was only adopted *after* all of Australia's customer countries had already concluded an Additional Protocol with no prompting or persuasion from Australia. Repeatedly Australia has demonstrated a reluctance to actively advance and strengthen non-proliferation initiatives.

ASNO states: "The non-proliferation regime is also strengthened through Australia's requirement that recipients of Australian obligated nuclear material adhere to the Additional Protocol." But Australia had nothing at all to do with that strengthening of the safeguards system. Instead of using Australia's position to leverage a positive outcome, Australia indulged in a cynical, retrospective PR exercise in relation to Additional Protocols.

New reactors types − proliferation-resistant?

Advocates of every conceivable type of reactor claim that their preferred reactor type is proliferation-proof or proliferation-resistant.

For example, a thorium enthusiast claims that thorium is "thoroughly useless for making nuclear weapons."[358] But the proliferation risks associated with thorium fuel cycles can be as bad as − or worse than − the risks associated with conventional uranium reactor technology.[359]

An enthusiast of integral fast reactors (IFR) claims they "cannot be used to generate weapons-grade material."[360] But IFRs can be used to produce plutonium for weapons.[361] Dr George Stanford, who worked on an IFR R&D program in the US, notes that proliferators "could do [with IFRs] what they could do with any other reactor − operate it on a special cycle to produce good quality weapons material."[362]

Nuclear advocates frequently make statements which are true, but misleading. For example, thorium itself is not a proliferation risk, but the uranium-233 that is produced when thorium is irradiated can be (and has been) used in weapons. And strictly speaking, it is true that IFRs "cannot be used to generate weapons-grade material" − because IFRs don't exist. And neither new or old reactor types can produce weapon grade plutonium or weapons-useable plutonium in the sense that plutonium cannot be used in weapons until it is separated from materials irradiated in a reactor, by reprocessing.

Fusion illustrates how difficult it is to disentangle the peaceful atom from its siamese twin, the military atom. Fusion has yet to generate a single Watt of useful electricity but it has already contributed to proliferation problems. According to Khidhir Hamza, a senior nuclear scientist involved in Iraq's weapons program in the 1980s: "Iraq took full advantage of the IAEA's recommendation in the mid 1980s to start a plasma physics program for "peaceful" fusion research. We thought that buying a plasma focus device ... would provide an excellent cover for buying and learning about fast electronics technology, which could be used to trigger atomic bombs."[363]

All existing and proposed reactor types and nuclear fuel cycles pose proliferation risks. The UK Royal Society notes: "There is no proliferation proof nuclear fuel cycle. The dual use risk of nuclear materials and technology and in civil and military applications cannot be eliminated."[364]

Likewise, John Carlson, former Director-General of the Australian Safeguards and Non-Proliferation Office, notes that "no presently known nuclear fuel cycle is completely proliferation proof".[365]

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[358] Tim Dean, 16 March 2011, 'The greener nuclear alternative', www.abc.net.au/unleashed/45178.html
[359] 'Thor-bores and uro-sceptics: thorium's friendly fire', Nuclear Monitor #801, 9 April 2015, www.wiseinternational.org/nuclear-monitors or www.foe.org.au/anti-nuclear/issues/nfc/power-weapons/thorium
[360] Barry Brook, 9 June 2009, 'An inconvenient solution', The Australian, http://bravenewclimate.com/2009/06/11/an-inconvenient-solution/
[361] Friends of the Earth, Australia, 'Nuclear Weapons and 'Generation 4' Reactors', www.foe.org.au/anti-nuclear/issues/nfc/power-weapons/g4nw
[362] George Stanford, 18 Sep 2010, 'IFR FaD 7 – Q&A on Integral Fast Reactors', http://bravenewclimate.com/2010/09/18/ifr-fad-7/
[363] Khidhir Hamza, Sep/Oct 1998, 'Inside Saddam's Secret Nuclear Program', *Bulletin of the Atomic Scientists*, Vol. 54, No. 5, www.iraqwatch.org/perspectives/bas-hamza-iraqnuke-10-98.htm
[364] UK Royal Society, 13 Oct 2011, 'Fuel cycle stewardship in a nuclear renaissance', http://royalsociety.org/policy/projects/nuclear-non-proliferation/report
[365] John Carlson, 2009, 'Introduction to the Concept of Proliferation Resistance', www.foe.org.au/sites/default/files/Carlson%20ASNO%20ICNND%20Prolif%20Resistance.doc

Proponents of new reactor types claim that proliferation-resistance is an important driver of technological innovation. However there is little or no evidence to support the claim. Moreover, precious few nuclear industry insiders or nuclear advocates show the slightest concern about proliferation problems such as the growing stockpiles of separated civil plutonium, or the inadequate safeguards system, or the troubling implications of opening up civil nuclear trade with non-NPT states such as India.

Climate scientist James Hansen states: "Nuclear reactors can also be made more resistant to weapons proliferation than today's reactors."[366] But *are* new reactors being made more resistant to weapons proliferation than today's reactors? In a word: No.

Hansen claims that "modern nuclear technology can reduce proliferation risks and solve the waste disposal problem by burning current waste and using fuel more efficiently."[367] While that is true, it is equally true that modern (Generation IV) technology could worsen proliferation problems. For example, India plans to produce weapons-grade plutonium in fast breeder reactors for use as driver fuel in thorium reactors.[368] Compared to conventional uranium reactors, India's plan is far worse on both proliferation and security grounds.

In a 2013 article, Pushker Kharecha and James Hansen wave away the proliferation problem with the assertion that they have "discussed it in some detail elsewhere".[369] But the paper they cite[370] barely touches upon the proliferation problem and what it does say about proliferation is mostly false:

- It falsely claim that thorium-based fuel cycles are "inherently proliferation-resistant".
- It claims that integral fast reactors "could be inherently free from the risk of proliferation". At best, integral fast reactors could reduce proliferation risks; they could never be "inherently free" from proliferation risks.
- And it states that if "designed properly", breeder reactors would generate "nothing suitable for weapons". India's Prototype Fast Breeder Reactor will be the next fast neutron reactor to begin operation (scheduled for September 2015). It will be ideal for producing weapon grade plutonium for India's weapons program, and it will likely be used for that purpose since India is refusing to place it under safeguards.[371]

Hansen and his colleagues argue that "modern nuclear technology can reduce proliferation risks".[372] India's Prototype Fast Breeder Reactor is modern − but it will exacerbate, not reduce, proliferation risks.

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[366] James Hansen, 7 June 2014, 'Scientists can help in planet's carbon cut', http://usa.chinadaily.com.cn/opinion/2014-06/07/content_17570035.htm

[367] 3 Nov 2013, 'Top climate change scientists' letter to policy influencers', http://edition.cnn.com/2013/11/03/world/nuclear-energy-climate-change-scientists-letter/index.html

[368] John Carlson, 2014, submission to Joint Standing Committee on Treaties, Parliament of Australia, www.aph.gov.au/DocumentStore.ashx?id=79a1a29e-5691-4299-8923-06e633780d4b&subId=301365

[369] Pushker Kharecha and James Hansen, March 2013, 'Prevented Mortality and Greenhouse Gas Emissions from Historical and Projected Nuclear Power', *Environment, Science and Technology*, http://pubs.acs.org/doi/abs/10.1021/es3051197

[370] P. Kharecha et al., 2010, 'Options for near-term phaseout of CO2 emissions from coal use in the United States', *Environmental Science & Technology*, 44, 4050-4062, http://pubs.acs.org/doi/abs/10.1021/es903884a

[371] John Carlson, 2015, first supplementary submission to Joint Standing Committee on Treaties, Parliament of Australia, www.aph.gov.au/DocumentStore.ashx?id=cd70cb45-f71e-4d95-a2f5-dab0f986c0a3&subId=301365

[372] K. Caldeira, K. Emanuel, J. Hansen, and T. Wigley, 3 Nov 2013, 'Top climate change scientists' letter to policy influencers', http://edition.cnn.com/2013/11/03/world/nuclear-energy-climate-change-scientists-letter/index.html

Misinformation advanced by nuclear advocates

Some nuclear advocates advance misinformation about proliferation and in particular the intersection between civil nuclear programs and proliferation. Much of their proliferation-related misinformation is debunked in a recent detailed paper[373] which covers the following topics:

1. Ignore the proliferation problem.
2. Define the problem out of existence.
3. Trivialize the proliferation problem.
4. Pay lip service to proliferation problems.
5. Fissile material is scarce?
6. Nuclear power is not a proliferation problem?
7. In some weapons states, nuclear power is insignificant or non-existent.
8. Weapons first, power later.
9. Weapons proliferation is a problem with or without nuclear power.
10. Climate change is more important than nuclear weapons proliferation?
11. Nuclear capable countries account for a large majority of greenhouse emissions.
12. The weapons genie is out of the bottle?
13. Reactor grade plutonium can't be used for weapons?
14. Specious parallels with other dual-use materials.
15. Determined proliferators can't be stopped ... so there's no point trying.
16. Strict safeguards prevent the misuse of the peaceful atom?
17. New reactors types are proliferation-proof?

A few pertinent examples are listed here:

> Trivialize the proliferation problem.
>
> Nuclear advocate Geoff Russell states that we have been 100% successful at preventing further use of nuclear weapons since World War II and that a "rational person would conclude that preventing nuclear wars and nuclear weapons proliferation is actually pretty easy, otherwise we wouldn't have been so good at it."[374] He further states: "The proliferation argument isn't actually an argument at all. It's just a trigger word, brilliantly branded to evoke fear and trump rational discussion." One of the organisations evoking fear and trumping rational discussion is the US State Department, which noted in a 2008 report that the "rise in nuclear power worldwide … inevitably increases the risks of proliferation".[375] And the US National Intelligence Council argued in a 2008 report that the "spread of nuclear technologies and expertise is generating concerns about the potential emergence of new nuclear weapon states and the acquisition of nuclear materials by terrorist groups."[376]
>
> Fissile material is scarce?

[373] 'The myth of the peaceful atom', 28 May 2015, Nuclear Monitor No. 804, www.foe.org.au/myth
[374] Geoff Russell, 2014, 'GreenJacked! The misdirection of environmental action on climate change', chapter 14, ISBN: 9-780980-656114
[375] Quoted in Sue Wareham, 6 Aug 2009, 'The terror of Hiroshima', www.onlineopinion.com.au/view.asp?article=9269&page=0
[376] US National Intelligence Council, 2008, "Global Trends 2025 – a Transformed World", http://web.archive.org/web/20081126005323/http://www.dni.gov/nic/PDF_2025/2025_Global_Trends_Final_Report.pdf

Academics Haydon Manning and Andrew O'Neil state that "the core ingredients of weapons-grade fissile material (i.e. highly enriched uranium and plutonium) are scarce internationally ..."[377]

A May 2015 report written by Zia Mian and Alexander Glaser for the International Panel on Fissile Materials provides details on stockpiles of fissile materials as of the end of 2013:

- Highly enriched uranium (HEU): 1,345 tons (936 tons military; 290 tons naval; 57 tons 'excess'; 61 tons civilian) − enough for 89,700 weapons (assuming 15 kg HEU/weapon).
- Plutonium: 498 tons (142 tons military; 89 tons 'excess'; 267 tons civilian) − enough for 129,700 weapons (assuming 3 kg of weapon grade plutonium or 5 kg of reactor grade plutonium per weapon).[378]

Mian and Glaser state that the global stockpile of fissile material contains more than 200,000 weapon-equivalents (219,400 using the above figures). The civilian stockpiles contain 57,070 weapons-equivalents: 61 tons of highly enriched uranium (4,070 weapons), and 267 tons of (separated) plutonium (53,000 weapons).

The figures are greater if plutonium in spent fuel is included. A 2005 report by the Institute for Science and International Security found that nuclear stockpiles contained over 300,000 weapon-equivalents:

- 1,830 tonnes of plutonium in 35 countries at the end of 2003, enough to make 225,000 nuclear bombs (assuming 8 kg/weapon), with civil plutonium stockpiles increasing by 70 tonnes per year. The figure for power and research reactor programs was 1,570 tonnes or 196,250 weapon-equivalents.
- 1,900 tonnes highly enriched uranium in more than 50 countries, enough for over 75,000 weapons (assuming 25 kg/weapon).
- more than 140 tonnes of neptunium-237 and americium in 32 countries, enough for 5,000 weapons.[379]

Nuclear power is not a proliferation problem?

Academic 'Research Fellow' Martin Boland states: "Historically, if a country wants to produce a nuclear bomb, they build reactors especially for the job of making plutonium, and ignore civilian power stations."[380]

John Carlson, former head of the Australian Safeguards and Non-proliferation Office, states: "I have pointed out on numerous occasions that nuclear power as such is not a proliferation problem – rather the problem is with the spread of enrichment and reprocessing technologies ..."[381]

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[377] Haydon Manning and Andrew O'Neil, 2007, 'Australia's Nuclear Horizon: Moving Beyond the Drumbeat of Risk Inflation', *Australian Journal of Political Science*, 42:4, 563-578, http://dx.doi.org/10.1080/10361140701595767 or www.tandfonline.com/doi/full/10.1080/10361140701595767

[378] Zia Mian and Alexander Glaser, 2015, 'Global Fissile Material Report 2015: Nuclear Weapon and Fissile Material Stockpiles and Production', International Panel on Fissile Materials, http://fissilematerials.org/library/ipfm15.pdf

[379] Institute for Science and International Security, 1 Jan 2005, 'Global Stocks of Nuclear Explosive Material – End 2003 (Updated 2005)', Chapters I and II, http://isis-online.org/isis-reports/detail/global-stocks-of-nuclear-explosive-materials/17 Rob Edwards, 7 Sep 2005, 'Nuclear stockpiles could create 300,000 bombs', *New Scientist*, www.robedwards.info/2005/09/nuclear_stockpi.html

[380] Martin Boland, 30 Dec 2013, 'Debunking myths on nuclear power (it's not for making bombs)', http://theconversation.com/debunking-myths-on-nuclear-power-its-not-for-making-bombs-20013

[381] John Carlson, 27 Nov 2006, supplementary submission 30.2 to the Joint Standing Committee on Treaties, Inquiry into Uranium Sales To China,

Such arguments are false, for several reasons.

Firstly, power reactors have been used directly in weapons programs:

- India refuses to place numerous power reactors under safeguards[382] and presumably uses (or plans to use) them for weapons production.
- The US has long used a power reactor to produce tritium for use in nuclear weapons.[383] And proponents of a 'Safe Modular Underground Reactor' proposed for South Carolina were kindly offering the reactor to produce tritium for weapons.[384]
- The 1962 test of sub-weapon-grade plutonium by the US may have used plutonium from a power reactor.
- The US operated at least one dual-use reactor (the Hanford 'N' reactor) to generate power and to produce plutonium for weapons.[385]
- Russia operated dual-use reactors to generate power and to produce plutonium for weapons.[386]
- Magnox reactors in the UK were used to generate power and to produce plutonium for weapons.[387]
- In France, the military and civilian uses of nuclear energy are "intimately linked".[388] France used the Phénix fast neutron power reactor to produce plutonium for weapons[389] and possibly other power reactors for the same purpose.
- North Korea has tested weapons using plutonium produced in its 'Experimental Power Reactor'.
- Pakistan may be using power reactor/s in support of its nuclear weapons program.

Secondly, separating enrichment and reprocessing on the one hand, and reactors on the other, misses the point that the purpose of enrichment is to produce fuel for reactors, and reactors are the only source of materials for reprocessing plants. Nuclear power programs provide cover and legitimacy for the acquisition of enrichment and reprocessing technology.

Similarly, one of the main justifications for the development of research and training reactors is, as the name suggests, research and training towards the development of nuclear power. Research reactors have been the plutonium source for weapons in India and Israel. Small amounts of

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www.aph.gov.au/Parliamentary_Business/Committees/House_of_Representatives_Committees?url=jsct/8august2006/subs2/sub30_2.pdf

[382] John Carlson, 15 April 2015, submission to Joint Standing Committee on Treaties, Parliament of Australia, www.aph.gov.au/DocumentStore.ashx?id=8c00f0a2-c00e-4885-99cb-a2894564d3f6&subId=301365

[383] US Government Accountability Office, Oct 2010, 'National Nuclear Security Administration Needs to Ensure Continued Availability of Tritium for the Weapons Stockpile', www.gao.gov/products/GAO-11-100

[384] Thomas Clements, 2012, 'Documents Reveal Time-line and Plans for "Small Modular Reactors" (SMRs) at the Savannah River Site (SRS) Unrealistic and Promise no Funding', http://aikenleader.villagesoup.com/p/documents-reveal-time-line-and-plans-for-small-modular-reactors-smrs-at-the-savannah-river-site-sr/840884

[385] Patrick Marshall, 4 Feb 2014, 'Hanford's N Reactor', HistoryLink.org Essay 10702, www.historylink.org/index.cfm?DisplayPage=output.cfm&file_id=10702

[386] Mark A. Prelas and Michael Peck, 12 Jan 2005, 'Nonproliferation Issues For Weapons of Mass Destruction', CRC Press, pp.88-89,
https://books.google.com.au/books?id=QmmZoVTyAKwC
https://books.google.com.au/books?id=QmmZoVTyAKwC&pg=PA88&lpg=PA89

[387] 'Magnox', accessed 24 May 2015, http://en.wikipedia.org/wiki/Magnox#Reactors_built

[388] Patrice Bouveret, Bruno Barrillot, and Dominique Lalanne, Jan/Feb 2013, 'Nuclear chromosomes: The national security implications of a French nuclear exit', *Bulletin of the Atomic Scientists*, 69: 11-17, http://bos.sagepub.com/content/69/1/11.full

[389] Mycle Schneider, 2009, 'Fast Breeder Reactors in France', *Science and Global Security*, 17:36–53, www.princeton.edu/sgs/publications/sgs/archive/17-1-Schneider-FBR-France.pdf

plutonium have been produced in research reactors then separated from irradiated materials in a number of countries suspected of or known to be interested in the development of a nuclear weapons capability − including Iraq, Iran, South Korea, North Korea, Taiwan, Yugoslavia, and possibly Romania.[390] There is little pretence that Pakistan's unsafeguarded Khushab reactors are anything other than military reactors, but the 50 MWt Khushab reactor has been described as a 'multipurpose' reactor.[391]

Nuclear power programs can facilitate weapons programs even if power reactors are not actually built. Iraq provides a clear illustration of this point. While Iraq's nuclear research program provided much cover for the weapons program from the 1970s until 1991, stated interest in developing nuclear power was also significant. Iraq pursued a 'shop till you drop' program of acquiring dual-use technology, with much of the shopping done openly and justified by nuclear power ambitions.[392]

According to Khidhir Hamza, a senior nuclear scientist involved in Iraq's weapons program:[393]

"Acquiring nuclear technology within the IAEA safeguards system was the first step in establishing the infrastructure necessary to develop nuclear weapons. In 1973, we decided to acquire a 40-megawatt research reactor, a fuel manufacturing plant, and nuclear fuel reprocessing facilities, all under cover of acquiring the expertise needed to eventually build and operate nuclear power plants and produce and recycle nuclear fuel. Our hidden agenda was to clandestinely develop the expertise and infrastructure needed to produce weapon-grade plutonium."

In addition to material contributions for weapons programs, civil nuclear programs can provide the necessary expertise. Ian Jackson discusses the overlap:[394]

"The physics of nuclear weapons is really a specialized sub-set of general nuclear physics, and there are many theoretical overlaps between reactor and weapon design. ... Indeed, when I myself changed career from working at Britain's civilian Atomic Energy Research Establishment (Harwell) to inspecting the military AWE Aldermaston nearly a decade later, I was surprised at the technical similarity of energy and bomb research. The career transition was relatively straightforward, perhaps signalling the intellectual difficulty of separating nuclear energy technology from that of nuclear weapons."

Civil nuclear programs can provide political impetus for weapons programs. In Australia, for example, the most influential proponent of the push for nuclear weapons in the 1960s was Philip Baxter, head of the Australian Atomic Energy Commission.[395]

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[390] Friends of the Earth, Australia, 'Research reactors and weapons proliferation', http://foe.org.au/sites/default/files/ResearchReactors-Weapons.doc

[391] World Nuclear Association, 'Nuclear Power in Pakistan', Updated April 2015, www.world-nuclear.org/info/Country-Profiles/Countries-O-S/Pakistan/

[392] David Albright and Mark Hibbs, April 1992, 'Iraq's shop-yill-you-drop nuclear program', *Bulletin of the Atomic Scientists*, Vol. 48, No. 3, www.iraqwatch.org/perspectives/bas-iraqshop-nuke-4-92.htm

[393] Khidhir Hamza, Sep/Oct 1998, 'Inside Saddam's Secret Nuclear Program', *Bulletin of the Atomic Scientists*, Vol. 54, No. 5, www.iraqwatch.org/perspectives/bas-hamza-iraqnuke-10-98.htm

[394] Ian Jackson, 2009, 'Nuclear energy and proliferation risks: myths and realities in the Persian Gulf', *International Affairs,* 85:6, pp.1157–1172, www.chathamhouse.org/publications/ia/archive/view/163055 or http://onlinelibrary.wiley.com/doi/10.1111/j.1468-2346.2009.00855.x/full

[395] Friends of the Earth, Australia, 'The push for nuclear weapons in Australia 1950s-1970s', www.foe.org.au/anti-nuclear/issues/oz/ozbombs/

In some weapons states, nuclear power is insignificant or non-existent?

John Carlson, then head of the Australian Safeguards and Non-Proliferation Office, claimed that "... in some of the countries having nuclear weapons, nuclear power remains insignificant or non-existent."[396]

This attempt to absolve nuclear power from proliferation problems ignores the direct use of power reactors to produce material for weapons, and the use of power programs to justify development of other facilities used in weapons programs (enrichment and reprocessing plants, and research and training reactors).

Of the 10 states that have produced nuclear weapons, eight have power reactors and North Korea has an 'Experimental Power Reactor'. The nine current weapons states account for 59% of the world's 'operable' reactors as of May 2015 (257/437).[397]

Weapons first, power later?

Academic 'Research Fellow' Martin Boland claims that "no country has developed indigenous nuclear weapons after deploying civilian nuclear power stations.[398] Likewise, John Carlson says: "If we look to the history of nuclear weapons development, we can see that those countries with nuclear weapons developed them before they developed nuclear power programs."[399]

Those claims are partly true, partly false and partly misleading. In some cases, reactors preceded weapons. India had three power reactors operating before its 1974 weapons test.[400] Pakistan had one power reactor operating before it developed weapons.[401] North Korea's 'Experimental Power Reactor' preceded its weapons program − and has been used to produce plutonium for weapons.

In some other countries, weapons programs did indeed predate the development of nuclear power − but power programs have still contributed to weapons production. Examples include the operation of dual-use power/plutonium reactors in the UK, US, France and Russia.

Weapons proliferation is a problem with or without nuclear power?

Academics Brook and Bradshaw state: "Nuclear weapons proliferation is a complex political issue, with or without commercial nuclear power plants ..."[402]

True, but civil nuclear programs are a significant part of the proliferation. Five of the 10 states that have built weapons did so with significant technical and material input and/or political cover from civil programs (or ostensibly civil programs) − South Africa, Pakistan, India, Israel and North Korea.

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[396] Carlson, John, 2000, "Nuclear Energy and Non-proliferation – Issues and Challenges: An Australian Perspective", Paper prepared for JAIF Symposium on Peaceful Uses of Nuclear Energy and Non-Proliferation, Tokyo, 9-10 March 2000.
[397] www.world-nuclear.org/info/Facts-and-Figures/World-Nuclear-Power-Reactors-and-Uranium-Requirements/
[398] Martin Boland, 30 Dec 2013, 'Debunking myths on nuclear power (it's not for making bombs)', http://theconversation.com/debunking-myths-on-nuclear-power-its-not-for-making-bombs-20013
[399] John Carlson, 2000, "Nuclear Energy and Non-proliferation – Issues and Challenges: An Australian Perspective", Paper prepared for JAIF Symposium on Peaceful Uses of Nuclear Energy and Non-Proliferation, Tokyo, 9-10 March 2000.
[400] http://world-nuclear.org/nucleardatabase/advanced.aspx
[401] http://world-nuclear.org/nucleardatabase/advanced.aspx
[402] B. Brook, and C. Bradshaw, 2014, 'Key role for nuclear energy in global biodiversity conservation', *Conservation Biology*, http://dx.doi.org/10.1111/cobi.12433

The use of civil nuclear facilities and materials for weapons research or weapons programs, or to advance weapons ambitions and to lower the lead-time for weapons production, has been commonplace. It has occurred in the following countries: Algeria, Argentina, Australia, Brazil, Egypt, France, India, Iran, Iraq, Israel, Libya, North Korea, Norway, Pakistan, Poland, Romania, Russia, South Africa, South Korea, Sweden, Switzerland, Syria, Taiwan, UK, US, and Yugoslavia.[403]

Overall, civil nuclear facilities and materials have been used for weapons R&D in over one-third of all the countries with a nuclear industry of any significance, i.e. with power and/or research reactors. The Institute for Science and International Security collates information on nuclear programs and concludes that about 30 countries have sought nuclear weapons and 10 succeeded – a similar strike rate of one-in-three.[404]

Former IAEA Director-General Mohamed El Baradei noted:[405]

"If a country with a full nuclear fuel cycle decides to break away from its non-proliferation commitments, a nuclear weapon could be only months away. In such cases, we are only as secure as the outbreak of the next major crisis. In today's environment, this margin of security is simply untenable."

Nuclear capable countries account for a large majority of greenhouse emissions.

Academics Brook and Bradshaw state that countries with nuclear power reactors account 80% of global greenhouse gas emissions, and the figure rises to over 90% including those nations that are actively planning nuclear deployment or already have research reactors. They conclude: "As a consequence, displacement of fossil fuels by an expanding nuclear-energy sector would not lead to a large increase in the number of countries with access to nuclear resources and expertise."[406]

The premise is correct − countries operating reactors account for a large majority of greenhouse emissions. But even by the most expansive estimate − Brook's[407] − less than one-third of all countries have some sort of weapons capability (they possess weapons, are allied to a weapons state, or they operate power and/or research reactors). So Brook and Bradshaw's conclusion − that nuclear power expansion "would not lead to a large increase in the number of countries with access to nuclear resources and expertise" − is not necessarily true.

The weapons genie is out of the bottle?

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[403] Friends of the Earth, Australia, 'Case Studies: Civil Nuclear Programs and Weapons Proliferation', http://foe.org.au/sites/default/files/CivMil-CaseStudies2010.doc

[404] Institute for Science and International Security, 'Nuclear Weapons Programs Worldwide: An Historical Overview', accessed 26 May 2015, http://isis-online.org/nuclear-weapons-programs/

[405] Mohamed El Baradei, 6 Dec 2005, 'Reflections on Nuclear Challenges Today', www.iaea.org/newscenter/statements/reflections-nuclear-challenges-today

[406] B. Brook, and C. Bradshaw, 2014, 'Key role for nuclear energy in global biodiversity conservation', *Conservation Biology*, http://dx.doi.org/10.1111/cobi.12433

[407] Barry Brook, 6 Nov 2009, 'Carbon emissions and nuclear capable countries', http://bravenewclimate.com/2009/11/06/carbon-emissions-nuclear-capable-countries/

Some nuclear advocates claim that the weapons 'genie is out of the bottle' and that we therefore need not concern ourselves about the proliferation risks associated with an expansion of nuclear power.[408]

However, of the world's 194 countries, 10 have produced weapons − just under 5%.

About 45 countries (about one-quarter of all nations) have the capacity to produce significant quantities of fissile material for nuclear weapons − they have power reactors, medium- to large-sized research reactors, enrichment and/or reprocessing technology.

The weapons genie is only part way out of the bottle. And a large majority of the countries that have the capacity to produce significant quantities of fissile material have that capacity from their civil programs − so the 'genie' argument is circular and disingenuous.

Reactor grade plutonium can't be used for weapons?

Some nuclear advocates claim that the 'reactor grade' plutonium routinely produced in power reactors cannot be used in weapons. For example Barry Brook claims that "plutonium that comes out of reactors ... is contaminated with different isotopes of plutonium which means that even if you had all of the facilities available to you that the Manhattan bomb designers had, you still wouldn't be able to use it to create a nuclear bomb."[409]

In fact, the 'reactor grade' plutonium produced during routine operation of a power reactor is not ideal for weapons, but can be used nonetheless.[410]

The US government has acknowledged that a successful test using reactor grade plutonium was carried out at the Nevada Test Site in 1962. The exact isotopic composition of the plutonium used in the 1962 test remains classified. It has been suggested that because of changing classification systems, the plutonium may have been fuel grade plutonium using current classifications; in any case it was certainly sub-weapon grade.

India Today reported that one or more of the 1998 tests in India used reactor grade plutonium[411] and the UK and North Korea may have tested bombs using reactor grade or fuel grade plutonium.[412]

The problem is exacerbated by the separation and stockpiling of plutonium produced in power reactors, such that it can be used directly in weapons. Stockpiles of separated civil plutonium amounted to 267 tons as of the end of 2013.[413]

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[408] Barry Brook, 6 Nov 2009, 'Carbon emissions and nuclear capable countries', http://bravenewclimate.com/2009/11/06/carbon-emissions-nuclear-capable-countries/

[409] ABC, 17 May 2010, 'Does Being Green mean Going Nuclear?', www.abc.net.au/rn/counterpoint/stories/2010/2901393.htm

[410] 'Can 'reactor grade' plutonium be used in nuclear weapons?', 6 June 2014, *Nuclear Monitor* #787, www.wiseinternational.org/node/4247

[411] Anon., October 10, 1998, "The H-Bomb", *India Today*.

[412] Jackson, Ian, 2009, 'Nuclear energy and proliferation risks: myths and realities in the Persian Gulf', *International Affairs* 85:6, pp.1157–1172, www.chathamhouse.org/publications/ia/archive/view/163055 or http://onlinelibrary.wiley.com/doi/10.1111/j.1468-2346.2009.00855.x/full

[413] Zia Mian and Alexander Glaser, 2015, 'Global Fissile Material Report 2015: Nuclear Weapon and Fissile Material Stockpiles and Production', International Panel on Fissile Materials, http://fissilematerials.org/library/ipfm15.pdf

Moreover it is possible to operate power reactors on a short cycle to produce weapon grade plutonium. A typical reactor (1,000 MWe) could produce around 200 kg of weapon grade plutonium annually − enough for 50 weapons.[414]

2.11 What security implications are created by the activities of conversion, enrichment, fabrication or reprocessing of nuclear fuel, or by further manufacturing activities, in South Australia? What is the evidence which suggests that such risks might materialise? Can they be addressed and by what means?

Risks include:[415]

- attacks on or theft from nuclear facilities (or transport vehicles) by individuals or sub-national groups;
- military strikes by nation-states on nuclear sites (primarily to prevent their use in weapons programs);
- sabotage / insider threats, such as the sabotage incident at Sellafield in 2000.

Historical examples of military strikes on nuclear plants include the following:

- Israel's destruction of a research reactor in Iraq in 1981.
- the United States' destruction of two smaller research reactors in Iraq in 1991.
- attempted military strikes by Iraq and Iran on each other's nuclear facilities during the 1980-88 war.
- Iraq's attempted missile strikes on Israel's nuclear facilities in 1991.
- Israel's bombing of a suspected nuclear plant in Syria in 2007.

Most of the above examples have been motivated by attempts to prevent weapons proliferation. Nuclear plants might also be targeted with the aim of widely dispersing radioactive material or, in the case of power reactors, disrupting electricity supply.

If and when nuclear-powered nations go to war, they will have to choose between shutting down their power reactors, or taking the risk of attacks potentially leading to widespread, large-scale dispersal of radioactive materials. Risks can be reduced, but not eliminated, by shutting down reactors in those circumstances. Other facilities are vulnerable, esp. high level waste stores and reprocessing plants. Some security analysts and commentators have described civil nuclear facilities as pre-deployed nuclear targets.

Nuclear physicist Richard Garwin poses these questions:[416]
"What happens with a failed state with a nuclear power system? Can the reactors be maintained safely? Will the world (under the IAEA and U.N. Security Council) move to guard nuclear installations against theft of weapon-usable material or sabotage, in the midst of chaos? Not likely."

Incidents at ANSTO's Lucas Heights site in southern Sydney include the following:[417]

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[414] Victor Gilinsky with Marvin Miller and Harmon Hubbard, 22 Oct 2004, 'A Fresh Examination of the Proliferation Dangers of Light Water Reactors', www.npolicy.org/article.php?aid=172
See also Zia Mian and M. V. Ramana, Jan/Feb 2006, 'Wrong Ends, Means, and Needs: Behind the U.S. Nuclear Deal With India', *Arms Control Today*, www.armscontrol.org/act/2006_01-02/JANFEB-IndiaFeature
[415] 27 March 2000, 'Sabotage inquiry at Sellafield under way', www.irishtimes.com/news/sabotage-inquiry-at-sellafield-under-way-1.260139
[416] Richard L. Garwin, 2001, 'Can the World Do Without Nuclear Power?', www.solarpeace.ch/solarpeace/Download/20010409_Garwin_NuclearPowerArticle.pdf
[417] Tilman Ruff, 2006, 'Nuclear Terrorism', EnergyScience Coalition Briefing Paper #10, www.energyscience.org.au/FS10%20Nuclear%20Terrorism.pdf

- 1983: nine sticks of gelignite, 25 kg of ammonium nitrate (usable in explosives), three detonators and an igniter were found in an electrical substation inside the boundary fence. A detonator was set off but did not detonate the main explosives. Two people were charged.
- 1984: a threat was made to fly an aircraft packed with explosives into the HIFAR reactor; one person was found guilty of public mischief.
- 1985: after vandalism of a pipe, radioactive liquid drained into Woronora river, and this incident was not reported for 10 days. In 1986 an act of vandalism resulted in damage to the sampling pit on the effluent pipeline.
- 2000: in the lead-up to the Sydney Olympics, New Zealand detectives foiled a plot to attack the Lucas Heights reactor by Afghan sympathisers of Osama bin Laden.
- 9 October 2001: NSW and Federal police conducted a search following a bomb threat directed at ANSTO.
- December 2001: Greenpeace activists easily breach security at the front gate and the back fence of Lucas Heights, some activists scale the reactor while another breaches the 'secure air space' in a paraglider.
- October 2003: French terror suspect Willy Brigitte deported from Australia and held on suspicion of terrorism in France; alleged to have been planning to attack the reactor and to have passed on bomb-making skills to two Australians.
- November 2005: multiple coordinated arrests of terrorist suspects in Sydney and Melbourne. Court documents reveal the Lucas Heights reactor was a potential target. Three of the eight alleged members of the Sydney terror cell had previously been caught near the reactor facility by police in December 2004, each alleged to have given different versions of what they had been doing.
- November 2005: a reporter and photographer were able to park a one-tonne van for more than half an hour outside the Lucas Heights back gate, protected by a simple padlock able to be cut with bolt-cutters, 800 m from the reactor. *The Australian* reported: "The back door to one of the nation's prime terrorist targets is protected by a cheap padlock and a stern warning against trespassing or blocking the driveway."[418]
- 2007: A man facing terrorism charges had purchased five rocket launchers allegedly stolen from the army. According to a witness statement, the accused purchaser said "I am going to blow up the nuclear place", an apparent reference to Lucas Heights.[419]

Matthew Bunn and Scott Sagan discuss the problem of insider threats in a paper − 'A Worst Practices Guide to Insider Threats: Lessons from Past Mistakes' − which forms part of a larger project on insider threats under the Global Nuclear Future project of the American Academy of Arts and Sciences.[420] A recent example was the apparent insider sabotage of a diesel generator at the San Onofre nuclear plant in the United States in 2012; the most spectacular was a 1982 incident in which an insider placed explosives directly on the steel pressure vessel head of a nuclear reactor in South Africa and detonated them − thankfully the plant had not yet begun operating. All known thefts of plutonium or highly enriched uranium appear to have been perpetrated by insiders or with the help of insiders. Similarly, most of the sabotage incidents that have occurred at nuclear facilities were perpetrated by insiders.

Bunn and Sagan look at past disasters caused by insiders and draw from them 10 lessons about what not to do. The lessons are as follows:
#1: Don't assume that serious insider problems are NIMO (Not In My Organization)

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[418] Jonathan Porter, 19 Nov 2005, 'Nuclear site left exposed at the back door', *The Australian*.
[419] Sally Neighbour, 2 July 2007, 'Nations linked by blood and Islam', *The Australian*.
Charles Ferguson, 9 Jan 2007, 'Nuclear risk could be an inside job',
www.smh.com.au/news/opinion/nuclear-risk-could-be-an-inside-job/2007/01/08/1168104921045.html
[420] Matthew Bunn and Scott Sagan, April 2014, 'A Worst Practices Guide to Insider Threats: Lessons from Past Mistakes', Occasional Paper, American Academy of Arts & Sciences, www.amacad.org/content/publications/publication.aspx?d=1425

#2: Don't assume that background checks will solve the insider problem
#3: Don't assume that red flags will be read properly
#4: Don't assume that insider conspiracies are impossible
#5: Don't rely on single protection measures
#6: Don't assume that organizational culture and employee disgruntlement don't matter
#7: Don't forget that insiders may know about security measures and how to work around them
#8: Don't assume that security rules are followed
#9: Don't assume that only consciously malicious insider actions matter
#10: Don't focus only on prevention and miss opportunities for mitigation

A number of problems with Australia's approach to nuclear security, and the nuclear security issue more generally, are discussed in the following article:

> ***Nuclear security and Australia's uranium exports***
> *8 April 2014, Online Opinion*
> *http://onlineopinion.com.au/view.asp?article=16197*
> *The March 24−25 Nuclear Security Summit (NSS) in the Netherlands was attended by representatives from over 50 countries. The NSS issued a banal communiqué, almost all of which was decided in advance. The closest the communiqué comes to substance is to identify a range of "voluntary measures" which states "may consider taking" such as publishing information about national laws, exchanging good practices, and further developing training of personnel involved in nuclear security. Elsewhere the communiqué is beyond parody: "Sharing good practices, without detriment to the protection of sensitive information, might also be beneficial."*
> *To be fair, useful work is being done in some countries to tighten nuclear security. But it's too little and too slow, and the concept of nuclear security is too narrowly defined. The very first dot-point in the NSS communiqué insists that "measures to strengthen nuclear security will not hamper the rights of States to develop and use nuclear energy for peaceful purposes".*
> *Victor Gilinsky, a former member of the US Nuclear Regulatory Commission, noted in 2009 that "even so-called arms controllers fall over themselves trying to establish their bona fides by supporting nuclear energy development and devising painless proposals ..." That mentality was in evidence at the NSS. Gilinsky advocates a reversal of priorities: "Security should come first − not as an afterthought. We should support as much nuclear power as is consistent with international security; not as much security as the spread of nuclear power will allow."*
> ***Nuclear security architecture***
> *The NSS website says that Summit participants "laid the basis for an efficient and sustainable nuclear security architecture, consisting of treaties, guidelines and international organisations." But there was no discussion, and no outcomes, regarding vital architecture such as the flawed Nuclear Non-Proliferation Treaty (NPT). The security threats posed by nuclear weapons arsenals were beyond the scope of the NSS, and the discussion on nuclear weapons was vacuous and steered well away from the failure of the nuclear weapons states to fulfil their NPT disarmament obligations. US President Barack Obama's ultra-lite contribution to the NSS went no further than a reworking of the old saying that a single nuclear bomb can ruin your whole day: "Just one nuclear weapon exploded in a city ... would badly destabilize our security, our economies, and our very way of life."*
> *Nor did the NSS produce any outcomes regarding another vital piece of nuclear architecture: the flawed safeguards system of the International Atomic Energy Agency (IAEA). A recent report about the safeguarding of nuclear fuel cycle facilities, by the Nuclear Proliferation Prevention Project at the University of Texas, concludes: "Theoretical solutions to improve IAEA safeguards have been discussed for decades. However, proprietary, economic, and sovereignty concerns have limited the extent to which countries and private companies have implemented these theoretical solutions. Even in states that cooperate with the IAEA and apply sophisticated accounting mechanisms, such as Japan, safeguards at fuel-cycle facilities currently cannot come*

close to achieving their explicit goal of providing timely warning of a suspected diversion of one bomb's worth of fissile material. The prospects are even worse in states that resist cooperation and may wish to keep open their weapons option, such as Iran, and at facilities that employ first-generation safeguards."

Yet the NSS did not even consider the safeguards system. The broad problem was succinctly explained by former South Australian Premier Mike Rann many years ago, before he decided that his political ambitions were more important than speaking truth to power: "Again and again it has been demonstrated here and overseas that when problems over safeguards prove difficult, commercial considerations will come first."

Australia's uranium customers

Nuclear security standards are demonstrably inadequate in a number of Australia's uranium customer countries. Nuclear security risk factors in Russia include political instability, ineffective governance, pervasive corruption, and the presence of groups determined to obtain nuclear materials. A March 2014 report by Harvard University's Belfer Center for Science and International Affairs notes that Russia has the world's largest nuclear stockpiles stored in the world's largest number of buildings and bunkers, and that underfunding raises serious questions about whether effective nuclear security and accounting systems can be sustained."

In a 2011 report, the US Director of National Intelligence discussed nuclear smuggling in Russia: "We assess that undetected smuggling of weapons-usable nuclear material has occurred, but we do not know the total amount of material that has been diverted or stolen since the dissolution of the Soviet Union. We judge it highly unlikely that Russian authorities have been able to recover all of the stolen material."

Nuclear security lapses have repeatedly made headlines in the USA over the past two years. Examples include:

- *the Air Force removed 17 officers assigned to guard nuclear-armed missiles after finding safety violations, potential violations in protecting codes and attitude problems;*
- *Air Force officers with nuclear launch authority were twice caught napping with the blast door open;*
- *an inspection by the Department of Energy's Inspector General found that Los Alamos National Laboratory failed to meet its goal of 99% accuracy in accounting for the lab's inventory of weapons-grade nuclear materials, including plutonium;*
- *a report by LBJ School of Public Affairs at Texas University detailed inadequate protection of US commercial and research nuclear facilities;*
- *at least 82 missile launch officers from an Air Force base in Montana face disciplinary action for cheating on monthly proficiency tests or for being aware of cheating and failing to report it. Former missile-launch control officer Bruce Blair said cheating "has been extensive and pervasive at all the missile bases going back for decades";*
- *missile launch officers in two different incidents were found to have violated security regulations designed to prevent intruders from seizing their ICBM-firing keys;*
- *nineteen officers at Minot Air Force Base, North Dakota, were forced to surrender their launch authority because of performance and attitude problems;*
- *the Navy has opened an investigation into accusations of widespread cheating by sailors at an atomic-reactor training school in South Carolina;*
- *the congressionally mandated Advisory Panel on the Governance of the Nuclear Security Enterprise says that drastic reforms are crucial to address "systemic" management shortcomings at the National Nuclear Security Administration; and*
- *former military contractor Benjamin Bishop will plead guilty to providing nuclear-arms secrets and other classified information to his Chinese girlfriend.*

Time magazine describes the most embarrassing lapse: "In the U.S. in 2012, an 82-year old nun and two other peace protestors broke into Y-12, a facility in Tennessee that contains the world's largest repository of highly enriched uranium (HEU) in metal form and until the incident was

colloquially known as "the Fort Knox of HEU" for its state-of-the-art security equipment. The nun bypassed multiple intrusion-detection systems because faulty cameras had not been replaced and guards at the central alarm station had grown weary of manually validating sensors that produced frequent false alarms. When the protestors started hammering on the side of a building that contains enough HEU for hundreds of weapons, the guards inside assumed the noise was coming from construction workers that they had not been told were coming. She and her fellow protestors were eventually challenged by a single guard."

The United States' credibility is also undermined by its failure to ratify the 2005 amendment to the Convention on the Physical Protection of Nuclear Materials and the International Convention on the Suppression of Acts of Nuclear Terrorism. Moreover US federal government budget requests and allocations for nuclear security have been reduced repeatedly since 2011, with programs such as the Global Threat Reduction Initiative, the International Material Protection and Cooperation program, Securing the Cities, and a program to replace HEU research reactor fuel with low-enriched uranium, suffering.

Another 'good news' story from the NSS was an announcement that Japan would send "hundreds of kilograms" of HEU and separated plutonium to the US. But Japan continues to expand its stockpile of 44 tons of separated plutonium (nine tons in Japan, 35 tons at reprocessing plants in Europe) and it continues to advance plans to start up the Rokkasho reprocessing plant which would result in an additional eight tons of separated plutonium annually. With no hint of irony, the US/Japan joint statement announcing the plan to send HEU and separated plutonium from Japan to the US concludes: "Our two countries encourage others to consider what they can do to further HEU and plutonium minimization."

There is a long history of lax nuclear security in Japan. The US has raised concerns about inadequate security at Rokkasho and other nuclear plants in Japan. In November 2013, Japan's Nuclear Regulation Authority admonished the Japan Atomic Energy Agency for failing to take appropriate measures to protect its Monju prototype fast-breeder reactor from potential terrorist attacks.

The March 2014 report by Harvard University's Belfer Center for Science and International Affairs details significant nuclear security gaps in a number of countries that import uranium − or want to import uranium − from Australia. For example it states that India's approach to nuclear security is "highly secretive"; the threats India's nuclear security systems must confront "appear to be significant"; India faces challenges "both from domestic terrorist organizations and from attacks by terrorist organizations based in Pakistan"; India also confronts "significant insider corruption"; and the risk of theft or sabotage in India "may be uncomfortably high".

So what is Australia doing?

So what is the Australian government doing about the vital problem of inadequate nuclear security standards in uranium customer countries? And what are the uranium mining companies operating in Australia doing about the problem? The short answer is: nothing. They adopt a head in the sand approach, just as they ignored the disgraceful nuclear safety standards in Japan that led to the Fukushima disaster.

There are simple steps that could be taken − for example uranium exports could be made contingent on customer countries ratifying the amendment to the Convention on the Physical Protection of Nuclear Materials, and the International Convention on the Suppression of Acts of Nuclear Terrorism.

Issues Paper #3: Electricity Generation

None of the questions invite a discussion on 'Generation IV' reactors although the topic is presumably of interest to the NFCRC. Thus 'Generation IV' concepts are discussed in response to question 3.2 (along with discussion on Generation II/III reactor technology).

3.1 Are there suitable areas in South Australia for the establishment of a nuclear reactor for generating electricity? What is the basis for that assessment?

The Australia Institute identified possible sites for nuclear power plants in a 2007 report.[421]

The study used four primary criteria:
1. Proximity to appropriate existing electricity infrastructure; sites close to the National Electricity Market, preferably near existing large generators.
2. Proximity to major centres of electricity demand.
3. Proximity to transport infrastructure to facilitate the movement of nuclear fuel, waste and other relevant materials.
4. Access to large quantities of water for reactor cooling.

Secondary criteria included the following:
1. Population density − sites with adequate buffers to populated areas.
2. Geological and seismological issues.
3. Atmospheric conditions − sites with low risk of extreme weather events and suitable pollution dispersion conditions.
4. Security risk − sites with low security risks (e.g. sufficient buffers to potentially hazardous areas).
5. Sensitive ecological areas − sites that pose minimal risk to important ecological areas.
6. Heritage and aesthetics − sites that pose minimal risk to important heritage areas.
7. Economic factors − sites that accommodate local economic and social factors.

Based on the above criteria, the report identified the following sites:

South Australia:
Mt Gambier / Millicent; Port Adelaide; Port Augusta and Port Pirie

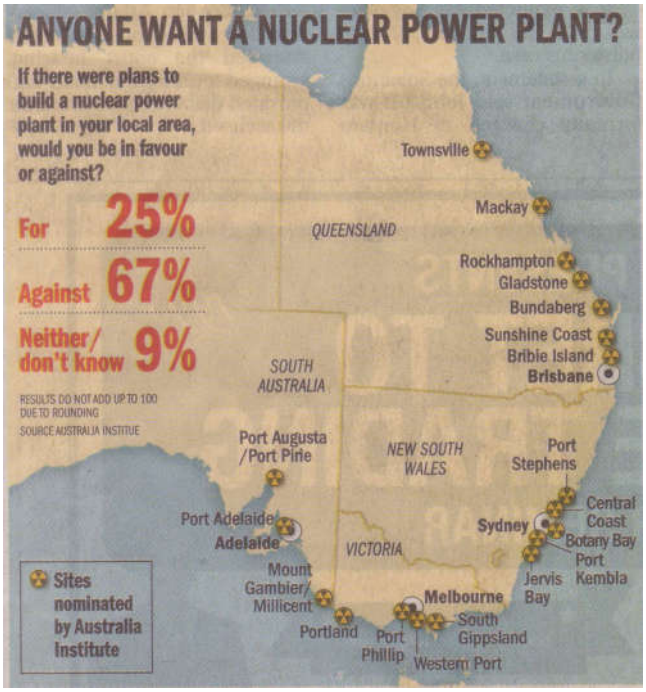
Queensland:
Townsville; Mackay; Rockhampton (e.g. around Yeppoon, Emu Park or Keppel Sands); Gladstone; Bundaberg; Sunshine Coast (e.g. near Maroochydore, Coolum or Noosa); Bribie Island area

New South Wales and the Australian Capital Territory:
Port Stephens (e.g. Nelson Bay); Central Coast (e.g. near Tuggerah Lakes); Port Kembla; Botany Bay; Jervis Bay and Sussex Inlet

Victoria:
South Gippsland (e.g. Yarram, Woodside, Seaspray); Western Port (e.g. French Island, Hastings, Kooweerup, Coronet Bay); Port Phillip (e.g. Newport, Werribee, Avalon); Portland

[421] Andrew Macintosh (The Australia Institute), 2007, 'Siting Nuclear Power Plants in Australia Where would they go?', www.tai.org.au/documents/downloads/WP96.pdf

Western Australia and the Northern Territory were excluded from the siting study because they are not on the National Electricity Market grid. The report did not consider Tasmania in any detail and considered it unlikely that a nuclear power plant would be constructed there in the short to medium term.



Regarding the SA sites, the Australia Institute provides the following information.

Mt Gambier / Millicent:
High earthquake risk. Four recorded earthquakes. Faults identified near Discovery Bay and north of Port MacDonnell.
Important heritage and ecological sites in the area include Canunda National Park and Nene Valley Conservation Park. The DEH website indicates that approximately 12 nationally listed threatened species and at least six listed migratory species are found in the area.
The Limestone Coast Tourism Region receives around 550,000 domestic overnight visitors, 630,000 domestic day visitors and 37,000 international visitors each year.

Port Adelaide:
High earthquake risk. 12 recorded earthquakes. Faults identified to the north and east of Adelaide. Faults also identified on the Yorke Peninsula.
Finding suitable sites with appropriate population buffers may be problematic (approximately 210,000 people were in the Port Adelaide/Enfield and Salisbury LGAs on census night in 2001).
There are a number of important heritage and ecological sites in the area, including Point Gawler Conservation Park, Barker Inlet – St Kilda Aquatic Reserve and St Kilda – Chapman Creek Aquatic Reserve. The DEH website indicates that approximately 14 nationally listed threatened species and at least 18 listed migratory species are found in the area.
The Adelaide Tourism Region receives around two million domestic overnight visitors, 2.8 million domestic day visitors and 300,000 international visitors each year. In 2002, it ranked amongst the top 10 regions visited by domestic and international tourists in Australia.

Port Augusta and Port Pirie:
High earthquake risk. 11 recorded earthquakes. Faults identified near Mt Grainger, to the northeast of Port Augusta and adjacent to Cowleds Landing.

There are a number of important heritage and ecological sites in the area, including Winninowie Conservation Park, Yatala Harbour Aquatic Reserve, Blanch Harbour – Douglas Bank Aquatic Reserve, Munyaroo Conservation Park and Whyalla – Cowleds Landing Aquatic Reserve. The DEH website indicates that approximately 20 nationally listed threatened species and at least 26 listed migratory species are found in the area.

3.2 Are there commercial reactor technologies (or emerging technologies which may be commercially available in the next two decades) that can be installed and connected to the NEM? If so, what are those technologies, and what are the characteristics that make them technically suitable? What are the characteristics of the NEM that determine the suitability of a reactor for connection?

This response to question 3.2 covers Generation III nuclear technology and then Generation IV concepts.

All of the options for short- to medium-term deployment of nuclear power reactors in Australia are problematic because of some combination of delays and cost overruns (e.g. AP1000, EPR), or safety issues (e.g. South Korea's APR1400), or because they are too early in the development phase to be comprehensively evaluated (e.g. CANDU EC6).

Generation III reactors

Introduction

Generation III reactor delays and problems are addressed in detail in the July 2015 edition of the World Nuclear Industry Status Report.[422] The report notes that none of the next-generation or so-called Generation III+ reactors has entered service, with EPR construction projects in Finland and France many years behind schedule. Of 18 reactors of Generation III+ design (eight Westinghouse AP1000, six Rosatom AES-2006, four AREVA EPR), 16 are delayed by between two and nine years. A number of causes for delays have been assessed: design issues, shortage of skilled labor, quality control issues, supply chain issues, poor planning, and shortage of finance. Standardisation did not take place, and the introduction of modularized design seems to have simply shifted the quality issues from construction sites to module factories. Serious defects found in several French pressure-vessel forgings could scuttle the entire EPR enterprise.

AP1000

Problems with Westinghouse AP1000 reactors are summarised by in a recent article by Chris Goodall:[423]

> *The AP1000 is the next generation design being developed by Westinghouse, a subsidiary of Toshiba. Westinghouse constructs the AP1000 projects in partnership with Chicago Bridge and Iron (CB&I), probably the world's most experienced builder of large power stations.*
> *The AP1000 is a 1.1 GW plant using a design based on a much smaller power station developed by Westinghouse 20 years ago. One important fact is that no stations using the original design were ever built. However, the advantages of the AP1000 are said to include a relatively simple design, a high level of passive safety and modular construction.*

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[422] Mycle Schneider, Antony Froggatt et al., July 2015, 'World Nuclear Industry Status Report 2015', www.worldnuclearreport.org/-2015-.html

[423] Abridged from Chris Goodall, 17 July 2015, 'Nugen's AP1000 nuclear reactor - is it any better than the EPR?', *The Ecologist*, www.theecologist.org/blogs_and_comments/Blogs/2952108/moorsides_ap1000_nuclear_design_is_any_better_than_the_epr.html

Modular construction means that components can be manufactured elsewhere and then shipped to the power station site. However US sites have had 5,000 workers on site at the same time, posing the some of the same huge management challenges that were experienced at the Finnish EPR site.

Four AP1000 reactors are in construction in the US and four in China. The US plants are at two separate sites in the state of Georgia ('Plant Vogtle', two AP1000s) and South Carolina ('Summer', two AP1000s).

I focus here on the experience in Georgia, but note that similar three-year delays have also happened at Summer in South Carolina, where serious cost overruns have also taken place.

Plant Vogtle - construction times more than doubled

Vogtle 3 and 4 are being built in the same complex as two earlier nuclear power stations. After delays in final design approval, they were finally licenced in February 2012. Near-concurrent construction of the two plants started in May 2013 with completion of the first planned for April 2016.

Original estimates for the total price to the utilities buying the power stations were about US$14bn (about £9.5bn). The price to be paid was essentially fixed, meaning that most of the construction risk is borne by Westinghouse and CB&I.

The most recent announcement of construction delays came in February 2015 when the station's eventual 45% owner (Georgia Power) told the state regulator that the partnership building the station had recently estimated that the eventual completion date for Vogtle 3 would be June 2019. Vogtle 4 would be finished in June 2020.

The expected delay for Vogtle 3 is now 39 months, more than doubling the initially expected construction time. The project is not yet half complete.

Costs are rising

Although the contract price has not risen significantly because it is largely fixed, the cost to electricity customers in the state of Georgia has increased. This is because the utilities that will eventually own the two new stations have been granted electricity price increases by the state regulator to cover the higher financing costs of Vogtle 3 and 4.

The utilities have been paying for individual elements of the two new plants as they are completed. The long delays mean that the interest costs are higher than expected and the regulator has already granted rate increases to compensate the eventual owners.

People in Georgia are already paying a supplement of 6% of their bills to finance the new nuclear station − Indeed Friends of the Earth US suggests that as much as 11% of their electricity bills may be supporting the project.

Although the deal was a fixed price contract, the company buying the largest share of the finished plants is in legal battles over extra costs that the contractors claim that the purchasers should bear.

We can reasonably expect that the cost to construct the stations has also increased. However industry estimates of the eventual final cost to the contractors are vague and imprecise. They currently seem to be around US$18bn (~£12bn). This seems low to me, given that the total project is now expected to take more than twice as long as originally expected.

CB&I says that Westinghouse will eventually pay most of the overrun costs but we can safely presume that this issue will also end up in court.

Georgia Power is losing faith in its contractors

Until recently the main buyer, Georgia Power, was reasonably content with the progress of the construction. However its 2015 submissions to the Georgia regulator have become increasingly concerned in response to the latest estimates of delay.

Note that Georgia Power has a difficult line to steer: it cannot be too critical of the contractors because otherwise the regulator that oversees it and grants its rate increases will question why it agreed to build the first new nuclear plant in the US for several decades in the first place!

Most recently, the company's May 2015 testimony prepared for a hearing has been openly critical of the contractors Westinghouse and CB&I:

"In general, the Company, like the other Owners, has been disappointed with the Contractor's performance under the revised IPS *(project plan)*. The Contractor has missed several key milestones since the publication of the revised IPS in January 2015, including several milestones relating to critical-path or near-critical-path activities such as the assembly of CA01 *(part of the central reactor)*, the delivery of shield building panels, and work on concrete outside containment.
"The Contractor has also encountered difficulties in ensuring that new vendors produce high-quality, compliant components per the IPS projections." *(p.15)*
Georgia Power is now indicating that it has little faith in the contractor's ability to keep to the new delayed timetable.
"The Contractor's schedule performance on critical path work such as concrete placements to start shield building installation and inside containment installation are challenges to the Contractor's ability to adhere to the revised IPS.
"The Contractor must continue to improve its schedule performance, maintain these improvements, and successfully resolve RCPs / squib valves / CMTs (*components with severe quality or delivery problems)* in order to complete the Facility by the currently projected substantial completion dates." *(p.15)*
China's AP1000s - a three year construction delay
Cost data from the Chinese construction projects is difficult to find. But they have also experienced significant construction difficulties. Building at Sanmen began construction in August 2009 and was originally expected to be finished by August 2013.
As with Vogtle, construction was said to be on schedule a year into the project and even in March 2012 completion was still officially planned for 2013. Recent updates suggests that completion will actually take place in 2016, also a three year delay.
The design used in China is simpler than that used in the US, and it may well be possible for Chinese constructors to build much more quickly and cheaply. However the modifications are unlikely to be acceptable to Western regulators. For example, the power stations are not designed to survive a direct hit from an airliner, a US requirement.
The questions in the minds of all concerned are surely these:

- *How many of the problems at Vogtle, Summer and elsewhere are inherent to the construction of a large third generation nuclear power station?*
- *And how many simply arise because these are 'first of a kind' projects?*
- *Will new nuclear projects around the world avoid the major problems that have affected the first eight AP1000s because the construction companies have learnt how to build these huge projects more efficiently?*
- *Or is a safe third generation nuclear power station beyond the capacity of even the most experienced contractors to build to a tight timetable and at a predictable cost?*

I'm afraid I don't think the answer is at all clear.
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Standardised, modular construction was meant to drive efficiencies and cost reduction. But those purported benefits have conspicuously failed to materialise with the AP1000 projects in the US (or with the EPR projects elsewhere). Modular construction "has not worked out to be the solution that the utilities promised", said Robert B. Baker, an energy lawyer and former member of the Georgia Public Service Commission, the state utility authority.[424]

[424] Rebecca Smith, 27 July 2015, 'Prefab Nuclear Plants Prove Just as Expensive' www.wsj.com/articles/pre-fab-nuclear-plants-prove-just-as-expensive-1438040802

EPR

The French EPR (European Pressurised Reactor, a.k.a. Evolutionary Power Reactor) seems destined for the chopping block.

In the UK, the estimated construction cost for an EPR in the mid- to late-2000s was £2 billion[425], while current estimates are 4-6 times higher. Current construction cost estimates for two planned large EPR reactors (totalling 3.2 GW) at Hinkley Point in Somerset range from £16 billion (A$30.6b) to the European Commission's estimate (which includes financing costs) of £24.5 billion (A$46.8b), or A$9.6−14.6 billion / GW.[426] EU Competition Commissioner Joaquin Almunia said the total cost could be as high as £34 billion (A$65.9b, A$20.6/GW), a figure that EDF Energy chief executive Vincent de Rivaz said included the maximum EDF could have to put into the project in a worst-case scenario if there were "huge problems".[427]

The UK government is offering loan guarantees of £10 billion (A$19.3b) for the Hinkley Point project. The UK government is also guaranteeing French utility EDF £89.50 (A$173.30) for every megawatt-hour generated by the Hinkley Point reactors, fully indexed for inflation, for 35 years. For comparison, the guaranteed payment of A$173.30/MWh is 2.7 times greater than typical wholesale electricity purchase costs in Australia of around A$65/MWh.[428] The legality of the subsidies is being challenged by Austria (and others) under EU regulations.

The estimated cost of the Flamanville EPR in France has increased from €3.3 billion (A$4.7b) to at least €9 billion (A$12.8b).[429] The first concrete was poured at Flamanville in 2007 and commercial operation was expected in 2012. That timeframe has been pushed back five years to 2017 (with further delays likely).[430] The British *Daily Mail* characterised the Flamanville EPR project as one "beset by financial mismanagement with rocketing costs, the deaths of workers, an appalling inability to meet construction deadlines, industrial chaos, and huge environmental concerns", and notes that "it continues to be plagued by delays, soaring costs, and litigation in both the criminal and civil courts."[431]

Since the contract was signed in 2003 for a new EPR in Finland, the estimated cost has risen from €3.2 billion (A$4.6b) to €8.5 billion (A$12.1b). Areva has already made provision for a €2.7 billion (A$3.8b) write-down on the project, with further losses expected.[432] French and Finnish utilities have been locked

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[425] www.energypost.eu/saga-hinkley-point-c-europes-key-nuclear-decision/
[426] European Commission, 8 Oct 2014, http://europa.eu/rapid/press-release_IP-14-1093_en.htm
[427] Emily Gosden, 8 Oct 2014, 'Hinkley Point nuclear plant to cost £24.5bn', www.telegraph.co.uk/finance/newsbysector/energy/11148193/Hinkley-Point-nuclear-plant-to-cost-34bn-EU-says.html
[428] NERA Economic Consulting, 19 Aug 2013, 'Wholesale Electricity Costs in the NEM', p.15, www.aemc.gov.au/getattachment/83698230-ac57-43b2-a8e0-e4bae4acce3f/NERA-Wholesale-Electricity-Costs-in-the-NEM.aspx
[429] 21 Apr 2015, France's nuclear calamity has UK worried, www.thelocal.fr/20150421/flamanville-frances-own-nuclear-nightmare
Carol Matlack, 16 April 2015, 'Areva Is Costing France Plenty', www.bloomberg.com/news/articles/2015-04-16/france-s-areva-falters-in-reactor-business-leaks-cash
[430] World Nuclear Association, March 2015, 'Nuclear Power in France', www.world-nuclear.org/info/Country-Profiles/Countries-A-F/France/
[431] Steve Bird, 26 Oct 2013, 'Deaths, chilling safety lapses, lawsuits, huge cost over-runs and delays: Why we can't trust the French with Britain's nuclear future', www.dailymail.co.uk/news/article-2477202/Deaths-chilling-safety-lapses-lawsuits-huge-cost-runs-delays-Why-trust-French-Britains-nuclear-future.html
[432] World Nuclear Association, April 2015, 'Nuclear Power in Finland', www.world-nuclear.org/info/Country-Profiles/Countries-A-F/Finland/

in legal battles for several years over the cost overruns.[433] The project is nine years behind schedule − the start-up date has been pushed back from 2009 to 2018.[434]

Plans for EPRs in other countries have been abandoned:[435]

> *Since the Fukushima disaster, a number of countries that might have considered EPRs pulled back from earlier interest in new reactors - the Netherlands, Sweden, and Switzerland, among others.*
> *In 2012, new-build tender processes in Finland and the Czech Republic rejected the EPR.*
> *In the US, a total of seven EPRs were planned at six sites. Four EPR construction licence applications were submitted to the Nuclear Regulatory Commission (NRC) but all four applications have been abandoned or suspended. In February 2015, Areva asked the NRC to suspend work on EPR design certification until further notice.*
> *EPRs were considered at various sites in Canada - including Alberta and Darlington, Ontario - but those plans were shelved and a generic licensing process by the Canadian Nuclear Safety Commission was terminated.*
> *In 2009, Italian utility Enel and EDF planned to build four EPRs but that plan was scrapped after Italy's June 2011 referendum which rejected nuclear power.*
> *In 2012, Enel pulled out of the Flamanville EPR project.*
> *The United Arab Emirates chose South Korean reactor technology over EPRs. Reflecting on that decision, former EDF head Francois Roussely concluded that while the EPR is* "one of the best" *third-generation designs, the complexity of the design is a* "handicap".
> *Likewise, Cambridge University nuclear engineer Tony Roulstone said in an October 2014 lecture that the EPR design is very safe but extraordinarily difficult to build - he described it as* "*unconstructable*".
> *According to the US's Nuclear Regulatory Commission (NRC), EPRs have four sets of active safety systems, each capable of cooling the reactor on its own, and other safety features including a double-walled containment and a 'core catcher' for holding melted reactor core materials after a severe accident. But the safety of some EPR design choices has been questioned by the French government's Institute for Radiological Protection and Nuclear Safety, and the EPR licensing process in the UK has been criticised.*

On 7 April 2015, the French Nuclear Safety Authority (ASN) announced that fabrication defects had been found in the reactor pressure vessel of the Flamanville EPR, forged by Areva's Creusot Forge subsidiary.[436] Tests revealed areas with high carbon concentration resulting in "lower than expected mechanical toughness values". Pierre-Franck Chevet, head of ASN, said: "It is a serious fault, even a very serious fault, because it involves a crucial part of the nuclear reactor."[437] Questions are being asked as to why the problem was not discovered before the vessel was installed.

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[433] World Nuclear News, 6 July 2012, 'Partial ruling on Olkiluoto 3', www.world-nuclear-news.org/-Arbitration_court_rules_on_Olkiluoto_3-0607124.html
World Nuclear Association, April 2015, 'Nuclear Power in Finland', www.world-nuclear.org/info/Country-Profiles/Countries-A-F/Finland/

[434] Reuters, 1 Sept 2014, 'Finland's nuclear plant start delayed again; Areva, TVO trade blame', www.reuters.com/article/2014/09/01/finland-nuclear-olkiluoto-idUSL5N0R20CV20140901

[435] Jim Green and Oliver Tickell, 15 May 2015, The Ecologist, 'Finland cancels Olkiluoto 4 nuclear reactor - is the EPR finished?', www.theecologist.org/News/news_analysis/2859924/finland_cancels_olkiluoto_4_nuclear_reactor_is_the_epr_finished.html

[436] Yves Marignac, WISE-Paris, April 2015, 'Fabrication Flaws in the Pressure Vessel of the EPR Flamanville-3', http://bit.ly/EPR_WISE-Paris

[437] John Lichfield, 18 April 2015, 'UK nuclear strategy faces meltdown as faults are found in identical French project', www.independent.co.uk/news/uk/home-news/uk-nuclear-strategy-faces-meltdown-as-faults-are-found-in-identical-french-project-10186163.html

The results of further tests are expected by October 2015. In one scenario, ASN will not require any remedial action and there will be minimal consequences for Areva. But if remedial action or replacement is required, it could be extremely expensive and problematic for Areva, all the more so because the pressure vessel has already been installed in the Flamanville EPR. Asked what would happen if tests were negative, Chevet said: "Either EDF abandons the project or it takes out the vessel and starts building a new one ... this would be a very heavy operation in terms of cost and delay."[438] In a worst-case scenario for Areva, the pressure vessel problem would kill the Flamanville reactor project. A former senior nuclear safety official told Le Parisien: "If the weakness of the steel is proved, I don't hold out much hope for the survival of the [Flamanville] EPR project."[439]

Chevet said the reactor vessels for the UK's two planned EPRs planned for Hinkley Point C could be affected as they have already been manufactured by the same company using the same manufacturing techniques.[440]

The two EPRs under construction in China might also be affected since the pressure vessels for those reactors were also made by Creusot Forge.[441] China will not load fuel at the Taishan EPRs until safety issues have been resolved, China's environment ministry said.[442] A senior manager of a Chinese nuclear company, speaking anonymously to the South China Morning Post, said: "The people responsible for this need to be sacked. It shouldn't have happened. All materials must be checked thoroughly before use - that's a basic requirement. The urgent task is to launch a quality inspection in Taishan as soon as possible. Each batch of materials varies slightly. We will cross our fingers and pray for the best."[443]

Bloomberg noted in an April 2015 article that Areva's EPR export ambitions are now in "tatters".[444]

CANDU EC6

It is too early to determine whether the latest version of Canadian CANDU heavy water moderated and cooled reactor technology will be subject to delays and cost overruns as the EPR and AP1000 programs have been. Plans for new reactors in Canada have stalled for various reasons.

The World Nuclear Association notes that the Enhanced Candu-6 (EC6) has been through a licensing process in Canada which "to a large extent clears the way for it to be built in Canada should a construction licence application be submitted, and will help its acceptance internationally, notably in Argentina, Romania and China."[445]

Refurbishment of existing CANDU reactors is following the industry norm of cost overruns and delays. Trade journal *Nuclear Engineering International* commented: "It must be noted, however, that the

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[438] http://uk.reuters.com/article/2015/04/17/areva-nuclear-idUKL5N0XE11320150417
[439] John Lichfield, 18 April 2015, 'UK nuclear strategy faces meltdown as faults are found in identical French project', www.independent.co.uk/news/uk/home-news/uk-nuclear-strategy-faces-meltdown-as-faults-are-found-in-identical-french-project-10186163.html
[440] John Lichfield, 18 April 2015, 'UK nuclear strategy faces meltdown as faults are found in identical French project', www.independent.co.uk/news/uk/home-news/uk-nuclear-strategy-faces-meltdown-as-faults-are-found-in-identical-french-project-10186163.html
[441] www.world-nuclear-news.org/C-Areva-reviews-forging-inspections-2204156.html
[442] http://in.reuters.com/article/2015/04/16/china-nuclear-areva-idINL4N0XD3AU20150416
[443] www.scmp.com/news/china/article/1762861/french-warning-nuclear-reactors-being-built-guangdong
[444] www.bloomberg.com/news/articles/2015-04-16/france-s-areva-falters-in-reactor-business-leaks-cash
[445] World Nuclear Association, www.world-nuclear.org/info/Country-Profiles/Countries-A-F/Canada--Nuclear-Power/ [Accessed 29 July 2015]

various CANDU refurbishment projects in Canada (Bruce, Pickering and New Brunswick) have tended to overrun on both time and budget."[446]

The UK is considering EC6 reactors for plutonium disposition. A 2014 paper by the UK Nuclear Decommissioning Authority states that the use of EC6 reactors is a "credible option" but mentions uncertainties, noting that "some of the fuel fabrication systems have not been delivered at full industrial scale for plutonium fuels", and that there "remains uncertainty over the extent of the fuel performance demonstration programme that would be required".[447] Thus the CANDU proposal "would require some development work, related mostly to fuel performance and industrialisation of fuel fabrication." The timeframe for disposition of the plutonium stockpile using CANDUs could range from 2 to 60 years according to the Nuclear Decommissioning Authority report.

South Korea's APR1400

Academic Steve Thomas from the University of Greenwich summarised South Korea's APR1400 in a July 2014 paper:[448]

> *Korea has a long history of using nuclear power, its first reactor coming on-line in 1977 and by 2014, it had 23 reactors in operation and five under construction. From the 1990s, it has been building a capability as an independent reactor vendor through licensing designs from US vendors. However, it was until 2009 that it attempted to enter the export market when it bid successfully for a tender to build four reactors for UAE.*
> *Its latest technology is based on the System 80+ design produced by US Combustion Engineering which received generic approval (expired in 2012) in 1997 from the US NRC. The intellectual property for this design passed to BNFL and now lies with Toshiba. However, Toshiba is not promoting the design and is therefore unlikely to place restrictions on sales. First construction in Korea for this design, designated APR1400, was in 2008, with subsequent units in 2009, 2012 and 2013, none of which is yet in service.*
> *In December 2009, the UAE ordered four nuclear reactors from Korea using APR1400 technology, beating opposition from consortia led by EDF (including GDF Suez, Areva NP, and Total with the EPR) and GE-Hitachi. The contract is with Korean Electric (KEPCO) to build and operate the reactors, the first coming on-line at an unspecified site in 2017 and the last by 2020. The terms of the deal and what is included are not clear, although the contract is reported to be worth $20.4 billion. The Korean bid was reported to be $16 billion lower than the French bid. Whether this bid is realistic or whether there is an element of loss-leader to launch the export drive will not be clear until the plants are complete and the costs known. Construction of the first units 1 and 2 started in 2012 and 2013 respectively.*
> *The CEO of Areva NP was particularly scathing about the safety feature in the Korean design. Nucleonics Week reported: 'She mentioned in particular that EPR's containment was designed to withstand the crash of a large jet aircraft and had a provision to prevent molten corium from penetrating the reactor basemat if the core melted through the reactor vessel. She likened the Korean reactor — which she said had neither such feature — to "a car without airbags and safety belts."'*

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[446] Steve Kidd, 15 Oct 2013, "Argentina—a possible return to new nuclear?", www.neimagazine.com/opinion/opinionargentina-a-possible-return-to-new-nuclear/
[447] UK Nuclear Decommissioning Authority, Jan 2014, 'Progress on approaches to the management of separated plutonium – Position Paper', www.nda.gov.uk/publication/progress-on-approaches-to-the-management-of-separated-plutonium-position-pape
[448] Steve Thomas, July 2014, 'Nuclear technology options for South Africa', http://earthlife.org.za/www/wp-content/uploads/2014/09/nuclear-cost_report1.pdf

Korean authorities acknowledge that the APR1400 would not meet US or European requirements particularly on aircraft crash protection and, for Europe, a core-catcher. If the UAE price was realistic, it is not clear how much of the price advantage over Areva NP's EPR would be lost if these features were included. However, Korea has signalled its intention to try to compete in the US and UK markets. In 2010, it announced it would submit its design to the NRC for regulatory review in 2012. However, when it finally submitted the design in September 2013, the NRC found it contained insufficient information. Korea plans to resubmit the application in December 2014. Its plans for UK are still at an early stage.

Since the success with the UAE tender, Korea has shown interest in a number of nuclear markets but appears to have no strong prospects for further sales. In Turkey, Korea withdrew from bidding because of KEPCO's insistence that the agreement to buy the power should be guaranteed by the Turkish government. It may be that this marks a reluctance to repeat the sort of risks it is incurring with the UAE deal.

Korea's image as a high quality nuclear operator building plants quickly and operating them reliably was seriously damaged by revelations of faked quality control documents. In November 2012, it emerged that quality control certificates for thousands of pieces had possibly been forged.

Two reactors were closed (Yongwang 5 and 6) and five others already off-line remained closed. The two Yongwang reactors were allowed back on-line in January 2013 but it was only after it was found that more than 2,000 parts (fuses, switches, cooling fans) had been given forged certificates and had to be replaced. Six other reactors were found to have significant numbers (100 to 300) of forged documents. Three more reactors were closed for seven months from May 2013 when it was found that tests for control cables had been fabricated. Nearly 130 employees at KHNP and its suppliers were indicted, and hundreds of others reprimanded internally as a result of this scandal. How far this event has damaged Korea's nuclear industry's reputation remains to be seen.

Russia's AES-2006

Russia's AES-2006 reactor technology is summarised in the July 2015 'World Nuclear Industry Status Report':[449]

The development of the AES-2006 is more complex than that of EPR or AP1000, partly because, while Rosatom is the umbrella organization for all the major Russian nuclear companies, there appears to be considerable overlap between different subsidiaries. There are two major nuclear design companies, Moscow Atomenergoproekt and Saint-Petersburg Atomenergoproekt, which generally have their own distinctive versions of the same basic design, including AES-2006. A third design company, Nizhniy Novgorod Atomenergoproekt, exists but does not seem to be as important as the other two. Rosatom presents the successive versions of the VVER (the Russian version of the PWR) as a smooth evolution with Rosatom emphasizing the additional safety features that each successive model included.

There were two early post-Chernobyl designs, AES-91/V-428 (Saint-Petersburg Atomenergoproekt) exported to China and AES-92/V-412 (Moscow Atomenergoproekt) exported to India. The reactor was essentially the same as its predecessor, VVER-1000/V-320), but with added safety systems including a core-catcher and some passive safety systems. Both models are still being offered, for example to markets like Jordan where the extra output of the AES-2006 would be difficult to accommodate.

The AES-2006 comes in two versions, V-392M designed by Moscow Atomenergoproekt with two

[449] Mycle Schneider, Antony Froggatt et al., July 2015, 'World Nuclear Industry Status Report 2015', www.worldnuclearreport.org/-2015-.html

units under construction at Novovoronezh, and V-491, designed by Saint-Petersburg Atomenergoproekt and under construction at the Leningrad, Belarus, and the Baltic sites, although work at the Baltic site was suspended in 2013 and appears unlikely to restart. It is not clear which versions would be exported to the numerous export orders Rosatom claims but on which construction has not started, such as Turkey and Vietnam. There are differences between the two variants in terms of their passive safety systems.
Work on a successor design, VVER-TOI/V-520 developed by Moscow Atomenergoproekt and based on V-392M, quickly started and by 2010, it was said the new design would be available from 2012, although by 2015 no orders had been placed. VVER-TOI was expected to be 20 percent cheaper and could be built in 40 months.
First concrete was poured for the reactors sited in Russia from 2008–10 and these reactors are where substantive experience exists. The major reported incident was the collapse of the steel structures for a containment build at the Leningrad site in 2011. It was only in 2014 that first reports of delays emerged and by 2015, all four reactors were 3–4 years late. However, a January 2015 report from Russia's Audit Chamber seemed to put the blame squarely on shortage of funds. Whether there are other construction issues is difficult to tell. Two reactors using an older design at the Rostov site were ordered at about the same time as the AES-2006s; one of these was completed on time and the other appears close to schedule. It may be that this indicates more deep-seated issues at Novovoronezh and Leningrad than just shortage of capital. The record of AES-2006 seems somewhat better than that of EPR and AP1000, but the lack of detailed information on the AES-2006 projects and the lack of transparency of the regulatory system means it is difficult to draw strong conclusions on the buildability of the AES-2006 compared to AP1000 and EPR.

Generation IV reactor concepts

Introduction

So-called 'next generation' or 'Generation IV' reactor concepts are diverse. Some are far from new − in particular, variations of fast (a.k.a. fast spectrum or fast neutron) reactor technology have existed for decades and have a troubled history.

The politicking around Generation IV technology promotion is summarised by Jonathon Porritt:[450]

[T]he nuclear industry is now increasingly active in talking up the prospects for Generation IV reactor designs, which will (we are told) address all the same problems that Generation III designs were supposed to address. Right now, for instance, there's an outspoken lobby making the case for Small Modular Reactors – an idea which is readily badged as Generation IV but actually goes back to the 1960s. Then the 1980s. Then the 1990s. Then the early 2000s! As the International Energy Agency commented in 2002, in an era when it was rather more bullish about nuclear power: "The main reason for this stalemate is that we, in all our doings, continue to rely on nuclear technology developed in the 1950s, which had its roots in military applications which cannot exclude absolutely the possibility of a severe accident and which has reached its limits from an economic point of view."
For those who've now somewhat given up on Small Modular Reactors and other so-called "advanced nuclear reactors", there's always the promise of an entirely new nuclear value chain based not on uranium but on thorium – another proposition that has been around for more than 50 years. And what's remarkable here is that even the keenest advocates of thorium acknowledge

[450] Foreword in Mycle Schneider, Antony Froggatt et al., July 2015, 'World Nuclear Industry Status Report 2015', www.worldnuclearreport.org/-2015-.html

that it couldn't possibly make a substantive, cost-effective contribution to the world's need for low-carbon energy for at least another 20 years.
The consistent history of innovation in the nuclear industry is one of periodic spasms of enthusiasm for putative breakthrough technologies, leading to the commitment of untold billions of investment dollars, followed by a slow, unfolding story of disappointment caused by intractable design and cost issues. ***Purely from an innovation perspective, it's hard to imagine a sorrier, costlier and more self-indulgent story of serial failure.*** *(emphasis added)*

Decades away

The six Generation IV concepts being investigated by the Generation IV International Forum are: the gas-cooled fast reactor, the sodium-cooled fast reactor, the lead-cooled fast reactor, the molten salt reactor, the supercritical water-cooled reactor, and the very high temperature reactor.[451] The Generation IV International Forum brings together 12 countries with an interest in new reactor types, plus Euratom.[452]

The Generation IV International Forum states: "Depending on their respective degree of technical maturity, the first Generation IV systems are expected to be deployed commercially around 2030-2040."[453]

The Generation IV International Forum also states: "It will take at least two or three decades before the deployment of commercial Gen IV systems. In the meantime, a number of prototypes will need to be built and operated. The Gen IV concepts currently under investigation are not all on the same timeline and some might not even reach the stage of commercial exploitation."[454]

The International Atomic Energy Agency states: "Experts expect that the first Generation IV fast reactor demonstration plants and prototypes will be in operation by 2030 to 2040."[455]

A 2015 report by the French government's Institute for Radiological Protection and Nuclear Safety (IRSN) states: "There is still much R&D to be done to develop the Generation IV nuclear reactors, as well as for the fuel cycle and the associated waste management which depends on the system chosen."[456]

The World Nuclear Association noted in 2009 that "progress is seen as slow, and several potential designs have been undergoing evaluation on paper for many years."[457]

In January 2014, the Generation IV International Forum (GIF) released its 'Technology Roadmap Update for Generation IV Nuclear Energy Systems'. It updates the GIF 2002 Technology Roadmap.[458]

The GIF measures progress according to three (pre-commercialisation) phases:

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[451] www.gen-4.org/gif/jcms/c_40465/generation-iv-systems
[452] www.gen-4.org/gif/jcms/c_9335/charter
[453] www.gen-4.org/gif/jcms/c_9260/public
[454] www.gen-4.org/gif/jcms/c_41890/faq-2
[455] Peter Rickwood and Peter Kaiser, 1 March 2013, 'Fast Reactors Provide Sustainable Nuclear Power for "Thousands of Years"', www.iaea.org/newscenter/news/2013/fastreactors.html
[456] Institute for Radiological Protection and Nuclear Safety, 2015, 'Review of Generation IV Nuclear Energy Systems', www.irsn.fr/EN/newsroom/News/Pages/20150427_Generation-IV-nuclear-energy-systems-safety-potential-overview.aspx Direct download: www.irsn.fr/EN/newsroom/News/Documents/IRSN_Report-GenIV_04-2015.pdf
[457] World Nuclear Association, 15 Dec 2009, 'Fast moves? Not exactly...', www.world-nuclear-news.org/NN_France_puts_into_future_nuclear_1512091.html
[458] www.gen-4.org/gif/jcms/c_60729/technology-roadmap-update-2013

- the viability phase, when basic concepts are tested under relevant conditions and all potential technical show-stoppers are identified and resolved;
- the performance phase, when engineering-scale processes, phenomena and materials capabilities are verified and optimised under prototypical conditions; and
- the demonstration phase, when detailed design is completed and licensing, construction and operation of the system are carried out, with the aim of bringing it to the commercial deployment stage.

The projections made in the 2002 Technology Roadmap have been revised as follows:
- *Gas-cooled fast reactor*: end of viability phase pushed back from 2012 to 2022; end of performance phase pushed back from 2020 to 2030.
- *Molten salt reactor*: end of viability phase pushed back from 2013 to 2025; end of performance phase pushed back from 2020 to 2030.
- *Sodium-cooled fast reactor*: end of viability phase pushed back from 2006 to 2012; end of performance phase pushed back from 2015 to 2022.
- *Supercritical-water-cooled reactor*: end of viability phase pushed back from 2014 to 2015; end of performance phase pushed back from 2020 to 2025.
- *Very-high-temperature reactor*: end of viability phase remains at 2010; end of performance phase pushed back from 2015 to 2025.
- *Lead-cooled fast reactor*: end of viability phase brought forward from 2014 to 2013; end of performance phase pushed back from 2020 to 2021.

Averaging across the six reactor concepts: the end of the viability phase has been pushed back by an average of 4.7 years, and the end of the performance phase has been pushed back by an average of 7.2 years. That is a lot of slippage in the 11 years since the 2002 Technology Roadmap − all the more so since the latest projections may prove to be as optimistic as those in the 2002 report. Demonstration phases and commercial phases are a very long way away.

Purported benefits

It is doubtful whether the purported benefits of Generation IV reactors will be realised.

The French government's Institute for Radiological Protection and Nuclear Safety reviewed the six concepts prioritised by the Generation IV International Forum and concludes:
"At the present stage of development, IRSN does not notice evidence that leads to conclude that the systems under review are likely to offer a significantly improved level of safety compared with Generation III reactors, except perhaps for the VHTR [Very High Temperature Reactor] ..."[459]

Moreover the VHTR system could bring about significant safety improvements, the Institute for Radiological Protection and Nuclear Safety states, "but only by significantly limiting unit power".[460]

Regarding Generation IV concepts, Hirsch et al. state:
"A closer look at the technical concepts shows that many safety problems are still completely unresolved. Safety improvements in one respect sometimes create new safety problems. And even the

[459] Institute for Radiological Protection and Nuclear Safety, 2015, 'Review of Generation IV Nuclear Energy Systems', www.irsn.fr/EN/newsroom/News/Pages/20150427_Generation-IV-nuclear-energy-systems-safety-potential-overview.aspx Direct download: www.irsn.fr/EN/newsroom/News/Documents/IRSN_Report-GenIV_04-2015.pdf
[460] Institute for Radiological Protection and Nuclear Safety, 2015, 'Review of Generation IV Nuclear Energy Systems', www.irsn.fr/EN/newsroom/News/Pages/20150427_Generation-IV-nuclear-energy-systems-safety-potential-overview.aspx Direct download: www.irsn.fr/EN/newsroom/News/Documents/IRSN_Report-GenIV_04-2015.pdf

Generation IV strategists themselves do not expect significant improvements regarding proliferation resistance. But even real technical improvements that might be feasible in principle are only implemented if their costs are not too high. There is an enormous discrepancy between the catch-words used to describe Generation IV for the media, politicians and the public, and the actual basic driving force behind the initiative, which is economic competitiveness."[461]

Some Generation IV concepts promise major advantages, such as the potential to use long-lived nuclear waste and weapons-usable material (esp. plutonium) as reactor fuel. However, fast neutron reactor technology might more accurately be described as failed Generation I technology. The history of fast reactors has largely been one of extremely expensive, underperforming and accident-prone reactors which have contributed more to WMD proliferation problems than to the resolution of those problems. The troubled history of fast reactors is detailed in a report by the International Panel on Fissile Materials.[462] Most of the countries that invested in fast reactor technology have since abandoned those efforts.

Not easily deterred, proponents hold out the prospect of a new generation of fast neutron reactors. For example a recent guest post on Prof. Barry Brook's website claims that Generation IV fast neutron reactors will be mass produced and "dominating the market by about 2030."[463] Yet the International Atomic Energy Agency states: "Experts expect that the **first Generation IV fast reactor demonstration plants and prototypes** will be in operation by 2030 to 2040."[464] (emphasis added)

Japan's Monju fast reactor operated for 205 days after it was connected to the grid in August 1995, and a further 45 days in 2010[465]; apart from that it has been shut-down because of a sodium leak and fire in 1996[466], and a 2010 accident when a 3.3 tonne refuelling machine fell into the reactor vessel.

The lifetime load factor of the French Superphenix fast reactor − the ratio of electricity generated compared to the amount that would have been generated if operated continually at full capacity − was a paltry 7%[467], making it one of the worst-performing reactors in history.

According to the World Nuclear Association, China has one very small experimental fast reactor, plans a larger 'Demonstration Fast Reactor' by 2023, and plans its first fast reactor "for commercial operation from 2030".[468] So China doesn't expect fast reactors to be dominating the market by 2030, as the guest-post on Brook's website claims. China may have one commercial fast reactor by 2030 ... but probably won't.

One of the reasons China's fast reactor program is moving ahead very slowly is that China is collaborating with Russia, and Russia's fast reactor program is moving ahead very slowly. The latest setback was the indefinite postponement of the planned BN-1200 fast reactor in Russia, with

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[461] Helmut Hirsch, Oda Becker, Mycle Schneider and Antony Froggatt, April 2005, 'Nuclear Reactor Hazards: Ongoing Dangers of Operating Nuclear Technology in the 21st Century', report prepared for Greenpeace International, www.greenpeace.org/international/press/reports/nuclearreactorhazards

[462] International Panel on Fissile Materials, Feb 2010, 'Fast Breeder Reactor Programs: History and Status', www.ipfmlibrary.org/rr08.pdf

On the use of fast reactors in support of weapons production, see also Mycle Schneider, 2009, 'Fast Breeder Reactors in France', *Science and Global Security*, 17:36–53, www.princeton.edu/sgs/publications/sgs/archive/17-1-Schneider-FBR-France.pdf

[463] http://bravenewclimate.com/2015/06/18/complaint-about-misleading-helen-caldicott-article-in-the-saturday-paper/

[464] www.iaea.org/newscenter/news/2013/fastreactors.html

[465] www.world-nuclear.org/info/Country-Profiles/Countries-G-N/Japan/

[466] https://en.wikipedia.org/wiki/Monju_Nuclear_Power_Plant#Monju_sodium_leak_and_fire

[467] www.princeton.edu/sgs/publications/sgs/archive/17-1-Schneider-FBR-France.pdf

[468] www.world-nuclear.org/info/country-profiles/countries-a-f/china--nuclear-power/

Rosenergoatom spokesperson Andrey Timonov saying that the pilot BN-800 reactor "must answer questions about the economic viability of potential fast reactors because at the moment 'fast' technology essentially loses this indicator [when compared with] commercial VVER units."[469] Another fast-neutron reactor project − the BREST-OD-300 − is stretching Rosatom's funds. Bellona's Alexander Nikitin said that Rosatom's "Breakthrough" program to develop the BREST-OD-300 reactor was only breaking Rosatom's piggy-bank.[470]

Fast reactors haven't helped to resolve weapons proliferation problems; on the contrary, France has used a fast reactor to produce plutonium for weapons and India plans to do the same in the coming years.

Most importantly, whether Generation IV concepts deliver on their potential depends on a myriad of factors − not just the resolution of technical challenges. India's fast reactor / thorium program illustrates how badly things can go wrong, and it illustrates problems that cannot be solved with technical innovation. John Carlson writes:
"India has a plan to produce [weapons-grade] plutonium in fast breeder reactors for use as driver fuel in thorium reactors. This is problematic on non-proliferation and nuclear security grounds. Pakistan believes the real purpose of the fast breeder program is to produce plutonium for weapons (so this plan raises tensions between the two countries); and transport and use of weapons-grade plutonium in civil reactors presents a serious terrorism risk (weapons-grade material would be a priority target for seizure by terrorists)."[471]

French government's IRSN report

The 2015 report[472] by the French government's Institute for Radiological Protection and Nuclear Safety (IRSN) is of particular significance, coming from a government which has invested heavily in nuclear technology. IRSN is a government authority with 1,790 staff under the joint authority of the Ministries of Defense, the Environment, Industry, Research, and Health.

The IRSN report focuses on the six Generation IV concepts prioritised by the Generation IV International Forum (GIF), which brings together 12 countries with an interest in new reactor types, plus Euratom. France is itself one of the countries involved in the GIF.

The report states: "There is still much R&D to be done to develop the Generation IV nuclear reactors, as well as for the fuel cycle and the associated waste management which depends on the system chosen."

IRSN considers the sodium-cooled fast reactor (SFR) system to be the only one to have reached a degree of maturity compatible with the construction of a reactor prototype during the first half of this century − and even the development of an SFR prototype would require further preliminary studies and technological developments.

The report says that for lead-cooled fast reactors and gas-cooled fast reactors systems, small prototypes might be built by mid-century. For molten salt reactors (MSR) and SuperCritical Water Reactors

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[469] World Nuclear News, 16 April 2015, 'Russia postpones BN-1200 in order to improve fuel design', www.world-nuclear-news.org/NN-Russia-postpones-BN-1200-in-order-to-improve-fuel-design-16041502.html
[470] Charles Digges, 8 June 2015, 'Is Russia postponing reactor builds over power surpluses or financial deficits?', http://bellona.org/news/nuclear-issues/2015-06-russia-postponing-reactor-builds-power-surpluses-financial-deficits
[471] John Carlson, 2014, first submission to Joint Standing Committee on Treaties, inquiry into Australia−India Nuclear Cooperation Agreement, Parliament of Australia, www.aph.gov.au/DocumentStore.ashx?id=79a1a29e-5691-4299-8923-06e633780d4b&subId=301365
[472] Institute for Radiological Protection and Nuclear Safety, 2015, 'Review of Generation IV Nuclear Energy Systems', www.irsn.fr/EN/newsroom/News/Pages/20150427_Generation-IV-nuclear-energy-systems-safety-potential-overview.aspx Direct download: www.irsn.fr/EN/newsroom/News/Documents/IRSN_Report-GenIV_04-2015.pdf

(SCWR) systems, there "is no likelihood of even an experimental or prototype MSR or SCWR being built during the first half of this century" and "it seems hard to imagine any reactor being built before the end of the century".

IRSN notes that it is difficult to thoroughly evaluate safety and radiation protection standards of Generation IV systems as some concepts have already been partially tried and tested, while others are still in the early stages of development.

The report is unenthusiastic about research into transmutation of minor actinides (long-lived waste products in spent fuel), saying that "this option offers only a very slight advantage in terms of inventory reduction and geological waste repository volume when set against the induced safety and radiation protection constraints for fuel cycle facilities, reactors and transport." It notes that ASN, the French nuclear safety authority, has recently announced that minor actinide transmutation would not be a deciding factor in the choice of a future reactor system.

The IRSN's findings on the six GIF concepts are briefly summarised here:

Sodium-cooled Fast Reactors (SFR)

- The main safety advantage is the use of low-pressure liquid coolant. The normal operating temperature of this coolant is significantly lower than its boiling point, allowing a grace period of several hours during loss-of-cooling events. The advantage gained from the high boiling point of sodium, however, must be weighed against the fact that the structural integrity of the reactor cannot be guaranteed near this temperature.
- The use of sodium also comes with a number of drawbacks due to its high reactivity not only with water and air, but also with MOX fuel.
- It seems possible for SFR technology to reach a safety level at least equivalent to that of Generation III pressurised water reactors, but IRSN is unable to determine whether it could significantly exceed this level, in view of design differences and the current state of knowledge and research.

Very High Temperature Reactors (VHTR)

- The VHTR benefits from the operating experience feedback obtained from High Temperature Reactors (HTR).
- This technology is intrinsically safe with respect to loss of cooling, which means that it could be used to design a reactor that does not require an active decay heat removal system. The VHTR system could therefore bring about significant safety improvements compared with Generation III reactors, especially regarding core melt prevention.
- VHTR safety performance can only be guaranteed by significantly limiting unit power.
- The feasibility of the system has yet to be determined and will chiefly depend on the development of fuels and materials capable of withstanding high temperatures; the currently considered operating temperature of around 1000°C is close to the transformation temperature of materials commonly used in the nuclear industry.

Lead-cooled Fast Reactors (LFR)

- Unlike sodium, lead does not react violently with water or air.
- The thermal inertia associated with the large volume of lead used and its very high density results in long grace periods in the event of loss of cooling.
- In addition, the high boiling point at atmospheric pressure is a guarantee of high margins under normal operating conditions and rules out the risk of coolant boiling.
- The main drawback of lead-cooled (or lead-bismuth cooled) reactors is that the coolant tends to corrode and erode stainless steel structures.

- LFR safety is reliant on operating procedures, which does not seem desirable in a Generation IV reactor.
- The highly toxic nature of lead and its related products, especially polonium-210, produced when lead-bismuth is used, raises the problem of potential environmental impact.
- IRSN is unable to determine whether the LFR system could guarantee a significantly higher safety level than Generation III reactors.
- Various technical hurdles need to be overcome before a reactor of this type could be considered.

Gas-cooled Fast Reactors (GFR)

- Given the current state of GFR development, construction of an industrial prototype reactor would not be technically feasible. GFR specifications are highly ambitious and raise a number of technological problems that are still a long way from being solved.
- From the safety point of view, the GFR does not display any intrinsic quality likely to lead to a significant improvement over Generation III reactors.

Molten Salt Reactors (MSR)

- The MSR differs considerably from the other systems proposed by the GIF. The main differences are that the coolant and fuel are mixed in some models and that liquid fuel is used.
- The MSR has several advantages, including its burning, breeding and actinide-recycling capabilities.
- Its intrinsic neutron properties could be put to good use as, in theory, they should allow highly stable reactor operation. The very low thermal inertia of salt and very high operating temperatures of the system, however, call for the use of fuel salt drainage devices. System safety depends mainly on the reliability and performance of these devices.
- Salt has some drawbacks − it is corrosive and has a relatively high crystallisation temperature.
- The reactor must also be coupled to a salt processing unit and the system safety analysis must take into account the coupling of the two facilities.
- Consideration must be given to the high toxicity of some salts and substances generated by the processes used in the salt processing unit.
- The feasibility of fuel salt processing remains to be demonstrated.

Super Critical-Water-cooled Reactors (SCWR)

- The SCWR is the only system selected by GIF that uses water as a coolant. The SCWR is seen as a further development of existing water reactors and thus benefits from operating experience feedback, especially from boiling water reactors. Its chief advantage is economic.
- While the use of supercritical water avoids problems relating to the phase change from liquid to vapour, it does not present any intrinsic advantage in terms of safety.
- Thermal inertia is very low, for example, when the reactor is shut down.
- The use of supercritical water in a nuclear reactor raises many questions, in particular its behaviour under neutron flux.
- At the current stage of development, it is impossible to ascertain whether the system will eventually become significantly safer than Generation III reactors.

Integral fast reactors

A number of Australian nuclear advocates are promoting a plan to import spent nuclear fuel (and possibly other forms of nuclear waste) and to process it for use as fuel in 'integral fast reactors' (IFRs). IFRs don't exist but they were the subject of an R&D program in the US for several decades.

That R&D program was not without controversy. Dr James Smith, a scientist who worked on an IFR R&D project in the US, was improperly pressured to resign from the project for raising concerns about defective work including fundamental errors in metallurgy and related sciences, at least some of which

had safety implications. He further claimed that Argonne National Laboratory published false and misleading accounts of its work. The Office of Nuclear Safety concurred with Dr Smith's claims that ANL failed to act on his proposals for improving how errors are detected.[473]

IFR/ADR/PRISM − US Department of Energy report

On the basis of the R&D program in the US, GE Hitachi says it is willing to build an IFR − which it calls 'Power Reactor Innovative Small Module' (PRISM) − if it can find a customer. The US and UK governments have shown some interest in the use of IFRs for plutonium disposition (providing proliferation resistance to separated plutonium stockpiles), and both governments published reports last year on the topic.

The Plutonium Disposition Working Group of the US Department of Energy (DoE) released a report in April 2014 which considers the use of Advanced Disposition Reactors (ADR) to manage US plutonium stockpiles (mostly surplus weapons plutonium).[474] The ADR concept is similar to General Electric Hitachi's PRISM according to the DoE.

The DoE's cost estimates for ADRs are as follows:
- 'capital project point estimate': US$9.42 billion.
- operating cost estimate US$33.41 billion.
- other program costs: US$7.62 billion.

Which gives a total of US$50.45 billion, or "more than $58 billion life cycle cost when sunk costs cost are included." That is twice as much as the next most expensive option for plutonium management:
- immobilisation (ceramic or glass) with high-level waste: US$28.65 billion.
- irradiation of MOX in light-water reactors: US$25.12 billion.
- downblending and disposal: US$8.78 billion.
- deep borehole disposal: no estimate provided.

The DoE report estimates that it would take 18 years to construct an ADR and associated facilities, with plutonium disposition beginning in 2033 and ending in 2075. Moreover, the DoE report states: "Final design of a commercial fast reactor would require significant engineering and licensing and as such carries uncertainties in being able to complete within the assumed duration."

On the technical challenges, the DoE report states:
"Irradiation of plutonium fuel in fast reactors ... faces two major technical challenges: the first involves the design, construction, start-up, and licensing of a multi-billion dollar prototype modular, pool-type advanced fast-spectrum burner reactor; and the second involves the design and construction of the metal fuel fabrication in an existing facility. As with any initial design and construction of a first-of-a-kind prototype, significant challenges are endemic to the endeavor, however DoE has thirty years of experience with metal fuel fabrication and irradiation. The metal fuel fabrication facility challenges include: scale-up of the metal fuel fabrication process that has been operated only at a pilot scale, and performing modifications to an existing, aging, secure facility ... Potential new problems also may arise

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[473] www.faqs.org/abstracts/Zoology-and-wildlife-conservation/Fusion-programme-could-aid-terrorists-California-to-keep-energy-labs-contracts.html
www.osti.gov/energycitations/product.biblio.jsp?osti_id=6030509
www.nature.com/nature/journal/v356/n6369/pdf/356469a0.pdf
https://inis.iaea.org/search/search.aspx?orig_q=RN:23040624

[474] US Department of Energy, April 2014, 'Report of the Plutonium Disposition Working Group: Analysis of Surplus Weapon Grade Plutonium Disposition Options', www.nnsa.energy.gov/sites/default/files/nnsa/04-14-inlinefiles/SurplusPuDispositionOptions.pdf

during the engineering and procurement of the fuel fabrication process to meet NRC's stringent Quality Assurance requirements for Nuclear Power Plants and Fuel Reprocessing Plants."

In short, the ADR option is associated with "significant technical risk" according to the DoE, and metal fuel fabrication faces "significant technical challenges" and has only been operated at the pilot scale.

IFR/PRISM/ADR advocates argued in 2011 that the first PRISM could be built in the US by 2016.[475] However the US Nuclear Regulatory Commission has yet to receive a licensing submission from GEH and there are no concrete plans for PRISMs in the US let alone any concrete pours. According to a November 2014 report, an updated safety assessment of PRISM will be conducted by Argonne National Laboratory with a multimillion-dollar investment from the US government.[476]

IFR/PRISM − UK report

The UK Nuclear Decommissioning Authority (NDA) released a position paper in January 2014 outlining potential options for future management of separated plutonium stockpiles.[477]

The options being considered for separated plutonium management in the UK are:

- Incorporating separated plutonium into mixed uranium−plutonium oxide MOX fuel for use in conventional light-water reactors;
- Reuse in Candu Energy 'Enhanced CANDU 6' reactors;
- Reuse in 'Power Reactor Innovative Small Module' (PRISM) fast reactors proposed by General Electric Hitachi (GEH)[478];
- Non-reuse options − long-term storage followed by disposal, or immobilisation followed by disposal.

The NDA report states that reuse in CANDU reactors "remains a credible option", that MOX is a "credible and technically mature option", while PRISM "should also be considered credible, although further investigation may change this view."

The NDA report states: "Currently, we believe there is insufficient understanding of the options to confidently move into implementation and consider that significant further work must be undertaken, focussing on technical and commercial risks and uncertainties ..."

General Electric Hitachi (GEH) proposes two 311 MWe PRISM reactors with the following processes:

- conversion of separated plutonium to a sodium-bonded U/Pu/Zr metal fuel using Direct Electrolytic Reduction, Pyroprocessing and metal casting techniques;
- irradiation of this metal fuel in PRISM reactors, in a burn rather than breed mode; and
- storage of the spent fuel pending disposal (no recycle of spent fuel, in line with current UK new nuclear build assumptions).

The NDA notes that the facilities required by the PRISM approach have not been industrially demonstrated, so further development work needs to be undertaken with the cost and time to complete this work yet to be defined in detail. GEH estimates that licensing these first of a kind PRISM reactors

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[475] 'Disposal of UK plutonium stocks with a climate change focus', http://bravenewclimate.com/2011/06/04/uk-pu-cc/

[476] Maxx Chatsko, 23 Nov 2014, 'General Electric Company's Advanced Nuclear Reactor Just Got a Boost From the DOE', www.fool.com/investing/general/2014/11/23/general-electric-companys-advanced-nuclear-reactor.aspx

[477] UK Nuclear Decommissioning Authority, Jan 2014, 'Progress on approaches to the management of separated plutonium – Position Paper', www.nda.gov.uk/publication/progress-on-approaches-to-the-management-of-separated-plutonium-position-paper

[478] http://gehitachiprism.com

would take around six years. GEH envisages first irradiation (following development, licensing and construction) in 14−18 years but the NDA considers that timeframe "ambitious considering delivery performance norms currently seen in the UK and European nuclear landscape".

Internal 2011 emails, released under Freedom of Information laws, revealed that the NDA said it had carried out a "high-level assessment" of PRISM and "the technology maturity for the fuel, reactor and recycling plant are considered to all be low".[479]

The NDA states that it has carried out a 'Generic Disposability Assessment' which found that, "whilst challenging, a disposal safety case can probably be made for disposal of sodium bonded PRISM Spent Fuel derived from the irradiation of the plutonium stocks in the UK." GEH proposes methods to remove the sodium from spent fuel in the event that a disposability safety case cannot be made.

IFRs are promoted on the grounds that they could recycle spent fuel repeatedly, leaving only relatively short-lived fission products (with half lives of 10−30 years) to be disposed of as waste. But the aims of the UK PRISM proposal are far more modest. GEH's Eric Loewen says: "What we're proposing is to disposition it; that means irradiating it in the reactor so that the plutonium is fissioned and the material is at the same radiation standard as spent fuel."[480]

The NDA report states that GEH believes that PRISMs could be implemented "under commercial arrangements". But it is unclear what that means. GEH is seeking funding from the US Export-Import Bank.

GEH refuses to release estimates of PRISM capital and operating costs, saying they are "commercially sensitive".[481]

An August 2015 report states that the Candu option seems to be emerging as a favourite for plutonium disposition in the UK, and that GEH is 'hedging its bets' by working with Candu Energy to develop the Candu approach.[482]

Assessing the claims of IFR advocates

An IFR advocate claims that the "first one [1 GWe IFR] will probably cost around [US]$1 to $2 billion".[483] That claim is inconsistent with the information provided in the UK and US reports (albeit the case that the UK and US reports consider a range of costs in addition to capital costs).

An IFR advocate claims that GEH could get a PRISM reactor "up and running in 5 years – the PRISM is fully proven in engineering terms and basically ready to go."[484] That claim is inconsistent with the information provided in the UK and US reports (see above).

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[479] Rob Edwards, 24 Jan 2012, 'Plans for Sellafield plutonium reactor rejected', www.guardian.co.uk/environment/2012/jan/24/sellafield-plutonium-reactor-plans-rejected
[480] Stuart Nathan, 13 May 2013, 'Prism project: A proposal for the UK's problem plutonium', www.theengineer.co.uk/energy-and-environment/in-depth/prism-project-a-proposal-for-the-uks-problem-plutonium/1016276.article
[481] http://gehitachiprism.com/faqs/ [Accessed 30 July 2015]
[482] August 2015, 'Slow Progress on Plutonium Stockpiles', nuClear news No.76, www.no2nuclearpower.org.uk/nuclearnews/NuClearNewsNo76.pdf
[483] http://skirsch.com/politics/globalwarming/ifrQandA.htm
[484] Mark Lynas, 1 March 2012, 'UK moves a step closer to nuclear waste solution', www.marklynas.org/2012/03/uk-moves-a-step-closer-to-nuclear-waste-solution/

An IFR advocate claims that: "The most compelling reason to look seriously at the PRISM is that it can burn all the long-lived actinides in spent nuclear fuel, leaving only fission products with a roughly 300-year radioactive lifetime. This puts a very different spin on the eventual need for a geological repository."[485] That claim is inconsistent with the UK NDA report which raises questions about the 'disposal safety case' for sodium bonded PRISM spent fuel. Advocates would argue that IFRs could *theoretically* recycle spent fuel until nothing is left but relatively short-lived fission products. However attractive theories have a history of giving rise to significant problems, e.g. a global legacy of 270 tonnes of separated plutonium despite the theoretical attractiveness of reprocessing to facilitate waste disposal; a legacy of failed fast reactor projects; and failed white elephants such as the MOX and THORP plants at Sellafield (and numerous others around the world).

Advocates promote the 'proliferation resistance' of the IFR fuel cycle. Theoretically, IFRs could consume more plutonium than they produce, and plutonium would never be separated from other actinides in a modified form of reprocessing called pyroprocessing. But in the case of the UK:

- proliferation risks are heightened by separating plutonium from spent fuel;
- internal 2011 emails reveal that the NDA is concerned about increased proliferation risks from converting plutonium oxide powder into metal PRISM fuel: "This would introduce more security/proliferation risk."[486]; and
- PRISMs will incorporate plutonium into spent fuel ... which begs the question: why separate plutonium from spent fuel in the first place?

More generally, claims that IFRs would be proliferation-resistant do not stand up to scrutiny. For example an IFR advocate claims they "cannot be used to generate weapons-grade material."[487] But IFRs could be used to produce plutonium for weapons.[488] Dr George Stanford, who worked on an IFR R&D program in the US, notes that proliferators "could do [with IFRs] what they could do with any other reactor − operate it on a special cycle to produce good quality weapons material."[489]

IFR advocates claim that there is be very little risk of a serious accident. Such claims are often made about reactor concepts that exist only on paper and they should be treated with scepticism. As a nuclear industry insider puts it: "We know that the paper-moderated, ink-cooled reactor is the safest of all." He went on to warn that: "All kinds of unexpected problems may occur after a project has been launched."[490] Likewise, nuclear engineer David Lochbaum says that: "The IFR looks good on paper. So good, in fact, that we should leave it on paper. For it only gets ugly in moving from blueprint to backyard."[491] In addition to that pithy comment, Lochbaum discusses some of the technical issues and risks associated with IFRs, raising serious questions and doubts about the safety claims made by IFR advocates.

Thorium

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[485] www.marklynas.org/2012/03/uk-moves-a-step-closer-to-nuclear-waste-solution/
[486] Rob Edwards, 24 Jan 2012, 'Plans for Sellafield plutonium reactor rejected', www.guardian.co.uk/environment/2012/jan/24/sellafield-plutonium-reactor-plans-rejected
[487] Barry Brook, 9 June 2009, 'An inconvenient solution', The Australian, http://bravenewclimate.com/2009/06/11/an-inconvenient-solution/
[488] Friends of the Earth, Australia, 'Nuclear Weapons and 'Generation 4' Reactors', www.foe.org.au/anti-nuclear/issues/nfc/power-weapons/g4nw
[489] George Stanford, 18 Sep 2010, 'IFR FaD 7 – Q&A on Integral Fast Reactors', http://bravenewclimate.com/2010/09/18/ifr-fad-7/
[490] Quoted in Helmut Hirsch, Oda Becker, Mycle Schneider and Antony Froggatt, April 2005, 'Nuclear Reactor Hazards: Ongoing Dangers of Operating Nuclear Technology in the 21st Century', report prepared for Greenpeace International, www.greenpeace.org/international/press/reports/nuclearreactorhazards
[491] http://skirsch.com/politics/globalwarming/ifrUCSresponse.pdf

There is a great deal of rhetoric regarding thorium. For example:[492]

Thorium is a superior nuclear fuel to uranium in almost every conceivable way ... If there is such a thing as green nuclear power, thorium is it. ... For one, a thorium-powered nuclear reactor can never undergo a meltdown. It just can't. ... Thorium is also thoroughly useless for making nuclear weapons. ... But wait, there's more. Thorium doesn't only produce less waste, it can be used to consume existing waste.

Those claims do not stand up to scrutiny.

Readiness

The World Nuclear Association (WNA) notes that the commercialization of thorium fuels faces some "significant hurdles in terms of building an economic case to undertake the necessary development work." The WNA states:[493]
"A great deal of testing, analysis and licensing and qualification work is required before any thorium fuel can enter into service. This is expensive and will not eventuate without a clear business case and government support. Also, uranium is abundant and cheap and forms only a small part of the cost of nuclear electricity generation, so there are no real incentives for investment in a new fuel type that may save uranium resources.
"Other impediments to the development of thorium fuel cycle are the higher cost of fuel fabrication and the cost of reprocessing to provide the fissile plutonium driver material. The high cost of fuel fabrication (for solid fuel) is due partly to the high level of radioactivity that builds up in U-233 chemically separated from the irradiated thorium fuel. Separated U-233 is always contaminated with traces of U-232 which decays (with a 69-year half-life) to daughter nuclides such as thallium-208 that are high-energy gamma emitters. Although this confers proliferation resistance to the fuel cycle by making U-233 hard to handle and easy to detect, it results in increased costs. There are similar problems in recycling thorium itself due to highly radioactive Th-228 (an alpha emitter with two-year half life) present."

A 2012 report by the UK National Nuclear Laboratory states:[494]
"NNL has assessed the Technology Readiness Levels (TRLs) of the thorium fuel cycle. For all of the system options more work is needed at the fundamental level to establish the basic knowledge and understanding. Thorium reprocessing and waste management are poorly understood. The thorium fuel cycle cannot be considered to be mature in any area."

Fiona Rayment from the UK National Nuclear Laboratory states:[495]
"It is conceivable that thorium could be introduced in current generation reactors within about 15 years, if there was a clear economic benefit to utilities. This would be a once-through fuel cycle that would partly realise the strategic benefits of thorium.
"To obtain the full strategic benefit of the thorium fuel cycle would require recycle, for which the technological development timescale is longer, probably 25 to 30 years.
"To develop radical new reactor designs, specifically designed around thorium, would take at least 30 years. It will therefore be some time before the thorium fuel cycle can realistically be expected to make a significant contribution to emissions reductions targets."

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[492] Tim Dean, 16 March 2011, 'The greener nuclear alternative', www.abc.net.au/unleashed/45178.html
[493] www.world-nuclear.org/info/Current-and-Future-Generation/Thorium/
[494] UK National Nuclear Laboratory Ltd., 5 March 2012, 'Comparison of thorium and uranium fuel cycles', www.decc.gov.uk/assets/decc/11/meeting-energy-demand/nuclear/6300-comparison-fuel-cycles.pdf
[495] Stephen Harris, 9 Jan 2014, 'Your questions answered: thorium-powered nuclear', www.theengineer.co.uk/energy-and-environment/in-depth/your-questions-answered-thorium-powered-nuclear/1017776.article

Kirk Sorensen, founder of a US firm which aims to build a demonstration 'liquid fluoride thorium reactor' (a type of molten salt reactor − MSR), notes that "several technical hurdles" confront thorium-fuelled MSRs, including materials corrosion, reactor control and in-line processing of the fuel.[496]

Nuclear physicist Prof. George Dracoulis writes:
"MSRs are not currently available at an industrial scale, but test reactors with different configurations have operated for extended periods in the past. But there are a number of technical challenges that have been encountered along the way. One such challenge is that the hot beryllium and lithium "salts" – in which the fuel and heavy wastes are dissolved – are highly reactive and corrosive. Building a large-scale system that can operate reliably for decades is non-trivial. That said, many of the components have been the subject of extensive research programs."[10]

The 2015 report[497] by the French government's Institute for Radiological Protection and Nuclear Safety states that for molten salt reactors (MSR) and SuperCritical Water Reactors (SCWR) systems, there "is no likelihood of even an experimental or prototype MSR or SCWR being built during the first half of this century" and "it seems hard to imagine any reactor being built before the end of the century".

Thorium is no 'silver bullet'

Do thorium reactors potentially offer significant advantages compared to conventional uranium reactors?

Prof. George Dracoulis states: "Some of the rhetoric associated with thorium gives the impression that thorium is, somehow, magical. In reality it isn't."[498]

The UK National Nuclear Laboratory report argues that thorium has "theoretical advantages regarding sustainability, reducing radiotoxicity and reducing proliferation risk" but that "while there is some justification for these benefits, they are often over stated."[499] The report further states that the purported benefits "have yet to be demonstrated or substantiated, particularly in a commercial or regulatory environment." The report further states:
"Thorium fuelled reactors have already been advocated as being inherently safer than LWRs [light water reactors], but the basis of these claims is not sufficiently substantiated and will not be for many years, if at all."

Thorium and proliferation

Claims that thorium reactors would be proliferation-resistant or proliferation-proof do not stand up to scrutiny.[500] Irradiation of thorium-232 produces uranium-233, which can be and has been used in nuclear weapons.

The World Nuclear Association states:[501]

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[496] Stephen Harris, 9 Jan 2014, 'Your questions answered: thorium-powered nuclear', www.theengineer.co.uk/energy-and-environment/in-depth/your-questions-answered-thorium-powered-nuclear/1017776.article
[497] Institute for Radiological Protection and Nuclear Safety, 2015, 'Review of Generation IV Nuclear Energy Systems', www.irsn.fr/EN/newsroom/News/Pages/20150427_Generation-IV-nuclear-energy-systems-safety-potential-overview.aspx Direct download: www.irsn.fr/EN/newsroom/News/Documents/IRSN_Report-GenIV_04-2015.pdf
[498] George Dracoulis, 5 Aug 2011, 'Thorium is no silver bullet when it comes to nuclear energy, but it could play a role', http://theconversation.com/thorium-is-no-silver-bullet-when-it-comes-to-nuclear-energy-but-it-could-play-a-role-1842
[499] UK National Nuclear Laboratory Ltd., 5 March 2012, 'Comparison of thorium and uranium fuel cycles', www.decc.gov.uk/assets/decc/11/meeting-energy-demand/nuclear/6300-comparison-fuel-cycles.pdf
[500] www.foe.org.au/anti-nuclear/issues/nfc/power-weapons/thorium
[501] www.world-nuclear.org/info/Current-and-Future-Generation/Thorium/

"The USA produced about 2 tonnes of U-233 from thorium during the 'Cold War', at various levels of chemical and isotopic purity, in plutonium production reactors. It is possible to use U-233 in a nuclear weapon, and in 1955 the USA detonated a device with a plutonium-U-233 composite pit, in Operation Teapot. The explosive yield was less than anticipated, at 22 kilotons. In 1998 India detonated a very small device based on U-233 called Shakti V."

According to Assoc. Prof. Nigel Marks, both the US and the USSR tested uranium-233 bombs in 1955.[502]

Uranium-233 is contaminated with uranium-232 but there are ways around that problem. Kang and von Hippel note:[503]
"[J]ust as it is possible to produce weapon-grade plutonium in low-burnup fuel, it is also practical to use heavy-water reactors to produce U-233 containing only a few ppm of U-232 if the thorium is segregated in "target" channels and discharged a few times more frequently than the natural-uranium "driver" fuel."

John Carlson discusses the proliferation risks associated with thorium:[504]

The thorium fuel cycle has similarities to the fast neutron fuel cycle – it depends on breeding fissile material (U-233) in the reactor, and reprocessing to recover this fissile material for recycle. ...
Proponents argue that the thorium fuel cycle is proliferation resistant because it does not produce plutonium. Proponents claim that it is not practicable to use U-233 for nuclear weapons.
There is no doubt that use of U-233 for nuclear weapons would present significant technical difficulties, due to the high gamma radiation and heat output arising from decay of U-232 which is unavoidably produced with U-233. Heat levels would become excessive within a few weeks, degrading the high explosive and electronic components of a weapon and making use of U-233 impracticable for stockpiled weapons. However, it would be possible to develop strategies to deal with these drawbacks, e.g. designing weapons where the fissile "pit" (the core of the nuclear weapon) is not inserted until required, and where ongoing production and treatment of U-233 allows for pits to be continually replaced. This might not be practical for a large arsenal, but could certainly be done on a small scale.
In addition, there are other considerations. A thorium reactor requires initial core fuel – LEU or plutonium – until it reaches the point where it is producing sufficient U-233 for self-sustainability, so the cycle is not entirely free of issues applying to the uranium fuel cycle (i.e. requirement for enrichment or reprocessing). Further, while the thorium cycle can be self-sustaining on produced U-233, it is much more efficient if the U-233 is supplemented by additional "driver" fuel, such as LEU or plutonium. For example, India, which has spent some decades developing a comprehensive thorium fuel cycle concept, is proposing production of weapons grade plutonium in fast breeder reactors specifically for use as driver fuel for thorium reactors. This approach has obvious problems in terms of proliferation and terrorism risks.
A concept for a liquid fuel thorium reactor is under consideration (in which the thorium/uranium fuel would be dissolved in molten fluoride salts), which would avoid the need for reprocessing to separate U-233. If it proceeds, this concept would have non-proliferation advantages.
Finally, it cannot be excluded that a thorium reactor – as in the case of other reactors – could be used for plutonium production through irradiation of uranium targets.

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[502] Nigel Marks, 2 March 2015, 'Should Australia consider thorium nuclear power?', http://theconversation.com/should-australia-consider-thorium-nuclear-power-37850
[503] Jungmin Kang and Frank N. von Hippel, 2001, "U-232 and the Proliferation-Resistance of U-233 in Spent Fuel", *Science & Global Security*, Volume 9, pp.1-32, www.princeton.edu/sgs/publications/sgs/pdf/9_1kang.pdf
[504] John Carlson, 2009, 'Introduction to the Concept of Proliferation Resistance', www.foe.org.au/sites/default/files/Carlson%20ASNO%20ICNND%20Prolif%20Resistance.doc

Arguments that the thorium fuel cycle is inherently proliferation resistant are overstated. In some circumstances the thorium cycle could involve significant proliferation risks.

3.3 Are there commercial reactor technologies (or emerging technologies which may be commercially available in the next two decades) that can be installed and connected in an off-grid setting? If so, what are those technologies, and what are the characteristics that make them technically suitable? What are the characteristics of any particular off-grid setting that determine the suitability of a reactor for connection?

Small Modular Reactors

These comments address 'small modular reactors' (SMR).

The Energy Green Paper released in September 2014 by the Australian government is typical of the small-is-beautiful rhetoric: "The main development in technology since 2006 has been further work on Small Modular Reactors (SMRs). SMRs have the potential to be flexibly deployed, as they are a simpler 'plug-in' technology that does not require the same level of operating skills and access to water as traditional, large reactors."[505]

The rhetoric doesn't match reality. Interest in SMRs is on the wane. Thomas W. Overton, associate editor of POWER magazine, wrote in a September 2014 article:
"At the graveyard wherein resides the "nuclear renaissance" of the 2000s, a new occupant appears to be moving in: the small modular reactor (SMR). ... Over the past year, the SMR industry has been bumping up against an uncomfortable and not-entirely-unpredictable problem: It appears that no one actually wants to buy one."[506]

Overton notes that a central premise of SMR rhetoric is large-scale standardised manufacturing producing many identical plants:
"It's an attractive idea. But it's also one that depends on someone building that massive supply chain, since none of it currently exists. ... That money would presumably come from customer orders − if there were any."

Likewise, Glenn George from KPMG states:
"I think that investors are in a wait-and-see mode regarding development of the SMR market. ... Investors will want to see SMR learning-curve effects, but a chicken-and-egg situation is at work: Decreased cost comes from production of multiple units over time, yet such production requires investment in the first place."[507]

Dr Mark Cooper, Senior Fellow for Economic Analysis at the Institute for Energy and the Environment, Vermont Law School, notes that two US corporations are pulling out of SMR development because they cannot find customers (Westinghouse) or major investors (Babcock and Wilcox). Cooper points to some economic constraints:
"SMR technology will suffer disproportionately from material cost increases because they use more material per MW of capacity. Higher costs will result from: lost economies of scale; higher operating

[505] http://ewp.industry.gov.au/files/egp/energy_green_paper.pdf
[506] Thomas W. Overton, 1 Sept 2014, 'What Went Wrong with SMRs?', www.powermag.com/what-went-wrong-with-smrs/
[507] Peter Taberner, 3 March 2015, 'SMRs: private investors call for track record and big government orders', http://analysis.nuclearenergyinsider.com/small-modular-reactors/smrs-private-investors-call-track-record-and-big-government-orders

costs; and higher decommissioning costs. Cost estimates that assume quick design approval and deployment are certain to prove to be wildly optimistic."[508]

Westinghouse CEO Danny Roderick said in January 2014: "The problem I have with SMRs is not the technology, it's not the deployment − it's that there's no customers."[509]

Academics M.V. Ramana and Zia Mian state in their detailed analysis of SMRs:[510]
"Proponents of the development and large scale deployment of small modular reactors suggest that this approach to nuclear power technology and fuel cycles can resolve the four key problems facing nuclear power today: costs, safety, waste, and proliferation. Nuclear developers and vendors seek to encode as many if not all of these priorities into the designs of their specific nuclear reactor. The technical reality, however, is that each of these priorities can drive the requirements on the reactor design in different, sometimes opposing, directions. Of the different major SMR designs under development, it seems none meets all four of these challenges simultaneously. In most, if not all designs, it is likely that addressing one of the four problems will involve choices that make one or more of the other problems worse."

Likewise, Kennette Benedict, Executive Director of the *Bulletin of the Atomic Scientists*, states: "Small modular nuclear reactors may be attractive, but they will not, in themselves, offer satisfactory solutions to the most pressing problems of nuclear energy: high cost, safety, and weapons proliferation."[511]

Argentina is constructing a 27 MWe reactor − but the estimated cost of ARS3.5 billion[512] (A$521 million) equates to A$19.3 billion per 1000 MWe.

The July 2015 edition of the World Nuclear Industry Status Report includes a chapter on SMRs.[513] The Report summarises its findings:

> *The concept for Small Modular Reactors (SMR) has been around for decades. Over a dozen basic designs have been discussed.*
> *In the U.S., where the government has been funding SMR development since the 1990s, the Nuclear Regulatory Commission has still not received a licensing application for any SMR design.*
> *In Russia, a Floating Point Unit design, a sort of swimming reactor, was licensed in 2002. The construction of two reactors began in 2007 but has been delayed repeatedly, partly for financial reasons.*
> *In South Korea an SMR design called System-Integrated Modular Advanced Reactor (SMART) has been under development for 20 years. The design was approved by the regulator in 2012, but no unit has been sold.*
> *In China, one SMR of the high-temperature gas cooled reactor is under construction.*
> *In South Africa, the Pebble Bed Modular Reactor − for a long time considered the most advanced SMR project in the world − was abandoned in 2010, after public expenditure of about US$1 billion, because it attracted no private investors or customers. The design was never completed.*
> *India has been developing an Advanced Heavy Water Reactor (AHWR) since the 1990s, but none is under construction.*

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[508] www.nirs.org/reactorwatch/newreactors/cooper-smrsaretheproblemnotthesolution.pdf
[509] www.post-gazette.com/business/2014/02/02/Westinghouse-backs-off-small-nuclear-plants/stories/201402020074
[510] www.sciencedirect.com/science/article/pii/S2214629614000486
[511] http://thebulletin.org/are-small-nuclear-reactors-answer
[512] www.world-nuclear-news.org/NN-Construction-of-CAREM-underway-1002144.html
[513] See pp.68−78 in Mycle Schneider, Antony Froggatt et al., July 2015, 'World Nuclear Industry Status Report 2015', www.worldnuclearreport.org/-2015-.html

In February 2014, Argentina started construction on a small unit, based on the pressurized water reactor, called CAREM, a domestic design that has been under development since the 1980s, reportedly at a cost of US$17,000 per installed kWe, a record for reactors currently under construction in the world.
Despite extensive government aid, U.S. development of SMRs is gaining far less market traction than publicity, as SMRs are initially far costlier than uncompetitively costly large reactors, their postulated learning curve relies upon an ability to reduce their cost has never been demonstrated anywhere for nuclear technology, and they face a formidable competitive landscape dominated by efficiency and renewable technologies already decades ahead in capturing their own economies of mass production.

Former World Nuclear Industry executive Steve Kidd wrote in a June 2015 article:[514]

SMRs are heavily promoted today as a viable solution to some of the problems experienced by projects to build large light water reactors (LWRs). Assuming they are technically viable, the smaller capital expenditure needed to build a largely factory-built smaller unit and the shorter construction period are certainly attractive features. And if electricity production is moving away from large centralised generating units into a distributed power model, smaller nuclear units may still have a chance. They may have a chance today in remote areas in developed countries that don't have easy grid access.
Lower cost, however, doesn't necessarily mean better economics. Smaller nuclear reactors were developed back in the 1950s but the sensible decision was made to take advantage of nuclear's real unique selling proposition. That is the ability to produce huge quantities of electricity very reliably in one place, with a small fuel input and minimal environmental impact. Reactor units became progressively larger in an attempt to capture economies of scale in construction costs, but also (and very importantly) to minimise operating and maintenance (O&M) expenses. ...
The jury is still out on SMRs, but unless the regulatory system in potential markets can be adapted to make their construction and operation much cheaper than for large LWRs, they are unlikely to become more than a niche product. Even if the costs of construction can be cut with series production, the potential O&M costs are a concern. A substantial part of these are fixed, irrespective of the size of reactor.

South Korea may have found a model to unlock the potential of SMRs: collaboration with a repressive Middle Eastern state coupled with extensive nuclear technology transfer. There is real concern that such actions will fan proliferation risks and tensions in a volatile region.

In March 2015, the Korea Atomic Energy Research Institute (KAERI) signed a memorandum of understanding with Saudi Arabia's King Abdullah City for Atomic and Renewable Energy (KACARE) to carry out a three-year study to assess the feasibility of building two first-of-a-kind 'System Integrated Modular Advanced ReacTor' (SMART) reactors. SMART is a 100 MWe pressurized water reactor design which could be used for electricity generation and desalinization. The cost of building the first SMART reactor in Saudi Arabia is estimated at US$1 billion.[515]

Among other obstacles, the development of SMART technology has only lukewarm support from the South Korean government; it is no longer financially backed by Korea Electric Power Co. (Kepco); there is no intention to deploy SMART reactors in South Korea; and plans to build a demonstration plant in South Korea stalled.

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[514] Steve Kidd, 11 June 2015, 'Nuclear myths – is the industry also guilty?', www.neimagazine.com/opinion/opinionnuclear-myths-is-the-industry-also-guilty-4598343/
[515] WNN, 4 March 2015, 'Saudi Arabia teams up with Korea on SMART', www.world-nuclear-news.org/NN-Saudi-Arabia-teams-up-with-Korea-on-SMART-0403154.html

KACARE says that SMART intellectual property rights will be co-owned and that, in addition to the construction of SMART reactors in Saudi Arabia, the two countries aim to commercialise the technology and to promote it world-wide.[516]

The joint partnership − and the extensive technology transfer and training it entails − will take Saudi Arabia a long way down the path towards developing a latent nuclear weapons capability. Saudi officials have made no secret of the Kingdom's intention to pursue a weapons program if Iran's nuclear program is not constrained.[517]

Wall Street Journal reporters noted on 11 March 2015:
"As U.S. and Iranian diplomats inched toward progress on Tehran's nuclear program last week, Saudi Arabia quietly signed its own nuclear-cooperation agreement with South Korea. That agreement, along with recent comments from Saudi officials and royals, is raising concerns on Capitol Hill and among U.S. allies that a deal with Iran, rather than stanching the spread of nuclear technologies, risks fueling it."[518]

3.6 What are the specific models and case studies that demonstrate the best practice for the establishment and operation of new facilities for the generation of electricity from nuclear fuels? What are the less successful examples? Where have they been implemented in practice? What relevant lessons can be drawn from them if such facilities were established in South Australia?

France is held up to be a leader in nuclear power. However Areva chairman Philippe Varin noted in March that the company is in "crisis" due to deficient management of big reactor projects and Areva's failure to adapt to a weaker global market following the 2011 Fukushima accident.[519] Moreover (and more importantly), the French civil nuclear industry has contributed to weapons proliferation at home (e.g. the use of the Phenix reactor to produce plutonium for weapons) and abroad (there are numerous examples such as the supply of the reactor used by Israel to produce plutonium for weapons, and the supply of nuclear technology to Iraq).

The US is leading the world in demonstrating how *not* to manage nuclear waste with over US$10 billion wasted on the Yucca Mountain repository project. The February 2014 explosion in the Waste Isolation Pilot Plant − a deep underground waste repository in New Mexico − is another illustration of the mismanagement of nuclear waste in an advanced industrial country.

Canada faces huge controversy over the plan for a low- and intermediate-level radioactive waste repository near Lake Huron. Plans for a repository for high-level nuclear waste are a very long way from being realised − a site has not yet been chosen. The long list of accidents, incidents and allegations (e.g. tax evasion) surrounding Cameco is another cause for concern.[520]

Grossly inadequate safety and regulatory standards in Japan were well known and documented before the Fukushima, and those sub-standard practices and patterns are re-emerging under Prime Minister Abe's LDP government (see section 3.9).

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[516] KACARE, 3 March 2015, 'MOU's Signature', www.kacare.gov.sa/en/?p=1667
[517] 18 Sept 2014, 'Saudi Arabia's nuclear power program and its weapons ambitions', Nuclear Monitor, Issue #791, www.wiseinternational.org/node/4195
[518] Jay Solomon and Ahmed Al Omran, 11 March 2015, 'Saudi Nuclear Deal Raises Stakes for Iran Talks', www.wsj.com/articles/saudi-nuclear-deal-raises-stakes-for-iran-talks-1426117583
[519] Geert De Clercq, 4 March 2015, 'Loss-making Areva bets on cost cuts, EDF cooperation, China', www.reuters.com/article/2015/03/04/areva-results-idUSL5N0W60I420150304
[520] http://ccwa.org.au/sites/default/files/Appendix%207%20Cameco%20Incidents.pdf

3.7 What place is there in the generation market, if any, for electricity generated from nuclear fuels to play in the medium or long term? Why? What is the basis for that prediction including the relevant demand scenarios?

Few anticipated the stagnation of energy/electricity demand in Australia (and numerous comparable countries) over the past five years or so. Few anticipated the dramatic decline in the cost of renewables. No-one can confidently anticipate demand scenarios over the medium to long term in Australia − nor the trajectory of the energy sources that might meet that demand.

3.8 What issues should be considered in a comparative analysis of the advantages and disadvantages of the generation of electricity from nuclear fuels as opposed to other sources? What are the most important issues? Why? How should they be analysed?

Key issues for a comparative analysis are as follows:

- Carbon intensity (see section 3.11)
- Economics (see section 3.16)
- Safety (see section 3.13)
- Proliferation of Weapons of Mass Destruction (see section 2.12)
- Waste legacy (see section 4)
- Treatment of Indigenous people (see section 1.9)

Numerous other issues should be considered in comparative assessments, such as the extremely high water consumption of nuclear power plants (and to a lesser extent coal fired power plants).

In some countries, the issue of land requirements for energy infrastructure might be considered a key issue − along with related issues such as biodiversity impacts from land reclamation for energy infrastructure. However those issues are of less significance in Australia given the large land availability, Australia's renewable energy potential, and the viability of heavy reliance on power sources with relatively low land requirements (e.g. solar, wind) with limited need for power sources that can be more problematic (e.g. bioenergy).[521]

Conversely, the treatment of Indigenous people may be of little relevance in some countries but it is highly relevant in Australia. As discussed in section 1.9, uranium/nuclear projects in Australia have frequently involved dispossession of Aboriginal land, annulment of Native Title rights and interests, etc. Some examples are briefly reiterated here:

- The Olympic Dam copper/uranium mine enjoys exemptions from the SA Aboriginal Heritage Act.
- The Ranger uranium mine is exempt from the Aboriginal Land Rights Act.
- NSW legislation exempts uranium mines from provisions of the NSW Aboriginal Land Rights Act.
- The attempt to impose a national radioactive waste repository in SA involved the extinguishment of Native Title rights and interests.
- The attempt to impose a national radioactive waste repository in the NT involved legislation permitting the imposition of a radioactive waste repository on Aboriginal land with no consultation with, or consent from, Traditional Owners.
- Aboriginal people have limited legal ability to say no to nuclear activities on their traditional lands.

[521] Mark Diesendorf, June 2015, '100% Renewable Electricity for South Australia', www.conservationsa.org.au/images/100_Renewables_for_SA_Report_-_Dr_Mark_Diesendorf_-_web_version.pdf

Expansion of the nuclear industry would inevitably be accompanied with further cases of dispossession, weakened heritage protections, etc.

3.9 What are the lessons to be learned from accidents, such as that at Fukushima, in relation to the possible establishment of any proposed nuclear facility to generate electricity in South Australia? Have those demonstrated risks and other known safety risks associated with the operation of nuclear plants been addressed? How and by what means? What are the processes that would need to be undertaken to build confidence in the community generally, or specific communities, in the design, establishment and operation of such facilities?

The Fukushima disaster resulted from grossly inadequate safety and regulatory standards in Japan's nuclear industry. Standards have improved somewhat in the aftermath of the disaster but the collusive practices of Japan's 'nuclear village' are returning. In other words, if lessons were learnt from the disaster, they are already being forgotten. This repeats the situation the followed the Chernobyl disaster − stronger safety and regulatory standards for a time, followed by complacency, cost-cutting, governments ceding to industry calls to lower safety standards, etc.

The Fukushima disaster in Japan in 2011 involved nuclear reactor fuel meltdowns, explosions and fires. The 2012 report of Japan's Nuclear Accident Independent Investigation Commission (NAIIC) concluded that the Fukushima disaster was "a profoundly man-made disaster that could and should have been foreseen and prevented" if not for "a multitude of errors and wilful negligence that left the Fukushima plant unprepared for the events of March 11".[522]

Consequences

Consequences of the Fukushima disaster include:

- The World Health Organisation predicts an increase in the number of all solid cancers, breast cancer, leukaemia and thyroid cancer as a result of radioactive Fukushima fallout.[523] Based on UNSCEAR data on human radiation exposure, UK radiation biologist Dr Ian Fairlie estimates around 5,000 fatal cancers from Fukushima fallout.[524]
- A September 2012 editorial in *Japan Times* noted that 1632 deaths occurred during or after evacuation from the triple-disaster; and nearly half (160,000) of the 343,000 evacuees were dislocated specifically because of the nuclear disaster.[525] A January 2013 article in *The Lancet* notes that "the fact that 47 per cent of disaster-related deaths were recognised in Fukushima prefecture alone indicates that the earthquake-triggered nuclear crisis at the Fukushima power plant caused extreme hardship for local residents."[526]
- Around 160,000 people were evacuated specifically because of the Fukushima accident. Around 80,000 people remain evacuated as of January 2015.[527] The 2012 NAIIC report noted that evacuees "continue to face grave concerns, including the health effects of radiation exposure, displacement, the dissolution of families, disruption of their lives and lifestyles ..."[528] Two years later, the situation has

[522] Nuclear Accident Independent Investigation Commission, 2012, http://warp.da.ndl.go.jp/info:ndljp/pid/3856371/naiic.go.jp/en/
[523] www.who.int/mediacentre/news/releases/2013/fukushima_report_20130228/en/
[524] Ian Fairlie, 2 April 2014, 'New UNSCEAR Report on Fukushima: Collective Doses', www.ianfairlie.org/news/new-unscear-report-on-fukushima-collective-doses/
[525] 'Slow road to reconstruction', 19 Sept 2012, *The Japan Times*, www.japantimes.co.jp/?post_type=opinion&p=8338
[526] Ichiseki, Hajime, 19 Jan 2013, 'Features of disaster-related deaths after the Great East Japan Earthquake', The Lancet, Vol.381, Issue 9862, www.thelancet.com/journals/lancet/article/PIIS0140-6736%2813%2960091-4/fulltext
[527] Hiriko Ito, 30 Jan 2015, 'Officials resume lives in radiation-hit town in hope of paving way for mass return', http://ajw.asahi.com/article/0311disaster/fukushima/AJ201501300010
[528] Nuclear Accident Independent Investigation Commission, 2012, http://warp.da.ndl.go.jp/info:ndljp/pid/3856371/naiic.go.jp/en/

worsened for many evacuees. Around 60% of the remaining evacuees are still living in small temporary housing units.[529]

- Total direct and indirect costs of the disaster will be around US$500 billion according to a study by the American Society of Mechanical Engineers.[530]

The internationally accepted dose limit for members of the public from anthropogenic sources of 1 millisievert per year has been increased to 20 mSv p.a. in areas affected by Fukushima fallout. Assoc. Prof. Tilman Ruff gives some indication of the risks:
"To provide a perspective on these risks, for a child born in Fukushima in 2011 who was exposed to a total of 100 mSv of additional radiation in its first five years of life, a level tolerated by current Japanese policy, the additional lifetime risk of cancer would be on the order of one in thirty, probably with a similar additional risk of premature cardiovascular death."[531]

Australia's uranium companies and the Fukushima disaster

Australian uranium was used in the Fukushima reactors. In 2011, Mirarr Senior Traditional Owner Yvonne Margarula wrote to UN Secretary General Ban Ki Moon expressing her sadness at the devastation that uranium from the Ranger uranium mine was causing in Japan: "This is an industry we never supported in the past and want no part of in the future. We are all diminished by the events unfolding at Fukushima," Ms Margarula said.[532]

Uranium mining companies in Australia, and successive federal governments, turned a blind eye to serious problems in Japan's nuclear industry over a long period of time. Those problems included[533]:

- revelations in 2002 that TEPCO had systematically and routinely falsified safety data and breached safety regulations for 25 years or more;
- revelations in 2007 of over 300 incidents of 'malpractice' at Japan's nuclear plants;
- evidence that Japan's nuclear plants were poorly equipped to withstand earthquakes and tsunamis; and
- evidence of manifestly inadequate regulation.

The 2006 Switkowski Review was silent about the documented, serious safety and regulatory problems in Japan. Instead, it offered reassuring platitudes such as this:[534]

There is now an international consensus on the principles for ensuring the safety of nuclear power plants and international cooperation through bodies such as the International Nuclear Safety Group established by the IAEA. In addition to publishing safety standard guidance documents, the IAEA provides safety services and runs seminars, workshops, conferences and conventions aimed at promoting high standards of safety. There is also an international regime of inspections and peer reviews of nuclear facilities in IAEA member countries, which has legislative backing through the international Convention on Nuclear Safety which entered into force on 24 October 1996. The

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[529] SimplyInfo.org Fukushima Disaster Four Year Report, 10 March 2015, www.fukuleaks.org/web/?p=14550
[530] American Society of Mechanical Engineers, June 2012, 'Forging a New Nuclear Safety Construct: The ASME Presidential Task Force on Response to Japan Nuclear Power Plant Events', www.asme.org/getmedia/73081de8-e963-4557-9498-f856b56dabd1/Forging_a_new_nuclear_safety_construct.aspx
[531] Tilman Ruff, 2013, 'A Public Health Perspective on the Fukushima Nuclear Disaster', *Asian Perspective*, 37, pp.523–549, www.mapw.org.au/files/downloads/AP37-4_Tilman%20Ruff%20%281%29.pdf
[532] 11 March 2015, 'Four years on: Kakadu Traditional Owners remain saddened by ongoing Fukushima disaster', www.mirarr.net/media_releases/four-years-on-kakadu-traditional-owners-remain-saddened-by-ongoing-fukushima-disaster
[533] March 2012, 'Japan's nuclear scandals and the Fukushima disaster', www.foe.org.au/anti-nuclear/issues/nfc/power/japan
[534] Switkowski Review, 2006, 'Uranium Mining, Processing and Nuclear Energy Review', http://pandora.nla.gov.au/tep/66043

Convention on Nuclear Safety aims to achieve and maintain high levels of safety worldwide. All IAEA member states with operating nuclear power reactors are parties to the convention.

The return of the 'nuclear village' in Japan

The collusive and sub-standard practices of Japan's nuclear industry led to numerous accidents before the Fukushima accident, and they were a root cause of the Fukushima accident itself. As the NAIIC report said: "The accident was the result of collusion between the government, the regulators and TEPCO, and the lack of governance by said parties."[535]

The patterns that led to the Fukushima disaster are re-emerging in Japan.[536] In other words the 'nuclear village' is back in control. Junko Edahiro, chief executive of Japan for Sustainability and one of the people removed from an energy policy advisory committee by the Abe government, noted in November 2014:
"Now what we have is a situation where government officials and committees are back to doing their jobs as if the March 2011 disasters had never occurred. They have resumed what they had been doing for 30 or 40 years, focusing on nuclear power ... In Japan we have what some people refer to as a 'nuclear village': a group of government officials, industries, and academia notorious for being strongly pro-nuclear. There has been little change in this group, and the regulatory committee to oversee nuclear policies and operations is currently headed by a well-known nuclear proponent."[537]

Japan has steadily slipped down Reporters Without Borders global ranking for press freedom since the Fukushima disaster, from 11th in 2010 to 61st in the latest ranking.[538] Journalists have been threatened with 'criminal contempt' and defamation suits, and Japan's 'state secrets' law makes investigative journalism about Japan's nuclear industry a perilous undertaking.[539] Under the law, which took effect in December 2014, the government can sentence those who divulge government secrets − which are broadly defined − to a decade in jail.

3.10 If a facility to generate electricity from nuclear fuels was established in South Australia, what regulatory regime to address safety would need to be established? What are the best examples of those regimes? What can be drawn from them?

The comments below consider the federal nuclear regulator, the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), with a focus on problems that could be redressed.

There are serious problems with regulation in SA. One example was the FoI revelation in 2013 that the radiation plans for Olympic Dam were more than 15 years out of date, with the SA Environment Protection Authority acknowledging that an update was (long) overdue.[540] If not for the FoI application

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[535] Nuclear Accident Independent Investigation Commission, 2012, http://warp.da.ndl.go.jp/info:ndljp/pid/3856371/naiic.go.jp/en/
[536] 31 March 2015, 'Atomic zombies: Japan's 'nuclear village' is back in control', Climate Spectator, www.businessspectator.com.au/article/2015/3/31/policy-politics/atomic-zombies-japans-nuclear-village-back-control
[537] Junko Edahiro, Nov 2014, 'Toward a Sustainable Japan: Fukushima Accidents Show Japan's Challenges', JFS Newsletter No.147, www.japanfs.org/en/news/archives/news_id035110.html
[538] Reporters Without Borders: http://index.rsf.org/#!/index-details/JPN
Toko Sekiguchi, 13 Feb 2015, 'Japan Slips in Press Freedom Ranking', http://blogs.wsj.com/japanrealtime/2015/02/13/japan-slips-in-press-freedom-rankings/
[539] 12 March 2014, 'Japan – Nuclear lobby still gagging independent coverage three years after disaster', http://foreignaffairs.co.nz/2014/03/12/japan-nuclear-lobby-still-gagging-independent-coverage-three-years-after-disaster/
[540] Miles Kemp, 7 July 2013, 'Radiation leak plan 15 years out of date', The Advertiser, www.adelaidenow.com.au/business/olympic-dam-mine-radiation-leak-plan-15-years-out-of-date/story-fni6uma6-1226675659296

and the surrounding publicity, the radiation plans would likely be more than 17 years out of date and counting. Nuclear fuel cycle facilities − reactors, reprocessing plants etc. − are typically more hazardous that uranium mines and the SA government's demonstrated inability to properly monitor and regulate the uranium industry should rule out any development of nuclear fuel cycle facilities.

A number of criticisms of the ARPANS Bill were made in a June 1998 paper by lawyer Tim Robertson (from Frederick Jordan Chambers) prepared for the Sutherland Shire Council, e.g.:

- the Bill did not answer site-specific questions concerning the immunity of the ANSTO site from State environment, health and safety laws.
- the regulatory framework which the Bill established was not accountable, transparent, or fully independent.
- all regulatory functions are vested in the CEO not the Agency.
- the Bill provided wide exemptions for anything done for national security or defence purposes in relation to nuclear material or installations. Amorphous concepts such as reasonable likelihood of prejudice to national security or defence are the basis for refusing to abide by the CEO's direction or licence.

Recommendation 41: The Royal Commission should consider whether the national security provisions in the ARPANS Act are appropriate.

The ARPANS Act contained all the flaws identified in the ARPANS Bill by Mr. Robertson.

A draft ARPANS Bill had ARPANSA headed by a Board. That model was scrapped in favour of a single person − the CEO of ARPANSA − answerable to the Minister.

Recommendation 42: The Royal Commission should consider whether ARPANSA would be better served with a number of commissioners (along the lines of the US Nuclear Regulatory Commission) rather than a single CEO, and recommend accordingly.

The federal government undermined ARPANSA's independence by allowing the then Chief Executive of ANSTO, Helen Garnett, to sit on panel which interviewed applicants for the position of CEO of ARPANSA. When asked to comment on that process at a public meeting in March 1999, ANSTO's then Communications Manager John Mulcair said he thought Garnett's involvement was indefensible.

Recommendation 43: The Royal Commission should investigate the circumstances that led to ANSTO's Executive Director being involved in the selection of the founding CEO of ARPANSA, and make recommendations to prevent regulated bodies playing any role whatsoever in the selection regulatory personnel.

Maralinga 'clean-up'

Then ARPANSA CEO John Loy said in a 17 April 2000 media release that the Maralinga clean-up was "world best practice" although it clearly was not; for example shallow burial of plutonium in unlined trenches certainly would not be tolerated in the UK or the USA. ARPANSA officials made suggestions about options for managing contaminated debris − such as encasement with concrete − which were simply dropped when the Department and its consultants proposed cheaper, inferior options. The contaminated debris has been buried just a few metres below grade in an unlined trench. Shallow burial of long-lived waste does not even comply with Australian standards let alone qualify as 'world best practice'.[541]

[541] Alan Parkinson, DEST National Radioactive Waste Repository - A Second Round Submission to ARPANSA, 25/2/04.

Given that ARPANSA was willing to echo government falsehoods and propaganda in relation to the nuclear waste project at Maralinga in SA, there is legitimate concern that ARPANSA would do the same in relation to future nuclear proposals in SA including national or international waste repositories or stores, or nuclear fuel cycle facilities.

ARPANSA rarely had personnel on-site at Maralinga and thus its first-hand knowledge of the rehabilitation project was limited, as was its capacity to regulate the project.

Nuclear engineer Alan Parkinson wrote "The newly formed Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) also has not performed particularly well in its first major assignment - the Maralinga project."[542]

Waste / reactor linkages − lessons repeatedly not learnt

Then ARPANSA CEO John Loy repeatedly stated that a reactor construction licence would not be granted unless progress was made towards the establishment of a store for long-lived intermediate-level waste (LLILW). For example:

- Dr. Loy was quoted in the 3/8/00 St George and Sutherland Shire Leader saying: "... by the time a licence to construct is applied for ... the store would need to be pretty well on track so we would have confidence that it would be located and built by that time. ... Just kind of saying, 'we are going to have a store but we do not know where or when, but don't you worry about that', would not be good enough."
- "I have said ... that at the construction stage I would want to see progress towards a store. ... Should it proceed and go to a commissioning time, I would want to be very much assured that there would be a store."[543]

Yet a reactor construction licence was issued by ARPANSA, and later a reactor operating licence, without a LLILW store being in place, and without firm plans in place towards the establishment of a store, and with very little or no progress towards a final disposal site and facility for LLILW.

In his 1999 report justifying the decision to issue a licence to prepare a site for ANSTO's replacement research reactor, John Loy said:[544]
It is true that the waste repository proposal is still in the development stage, that the long-lived intermediate level waste storage facility is yet to be definitely planned and no decisions have been taken on final disposal of long-lived intermediate level waste. There are significant environmental, social and political issues that will need to be dealt with for these plans to come to fruition. The question for me in this application is whether, at least in principle, I could see that there was sufficient commitment to the current plan and the general availability of alternative approaches so as to be confident that a way through would be found in a reasonable timescale. I took into account that there is clear progress on the siting of a low level waste repository and a Government commitment to examine co-locating a store for long-lived intermediate level waste in association with the repository.

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www.foe.org.au/sites/default/files/ParkinsonARPANSA2004.doc
See also Alan Parkinson, "Maralinga: The Clean-Up of a Nuclear Test Site", Medicine and Global Survival, Volume 7, Number 2, February 2002. www.ippnw.org/pdf/mgs/7-2-parkinson.pdf

[542] Submission to the Senate Select Committee for an Inquiry into the Contract for a New Reactor at Lucas Heights, September 2000.

[543] Dr. Loy in evidence to the Senate Select Committee for an Inquiry into the Contract for a New Reactor, Canberra, 9 Feb 2001, p.553 of transcripts.

[544] CEO of ARPANSA, 22/9/99, Issue of a Licence to ANSTO to Prepare a Site for Replacement Research Reactor Facility.

By the time Dr. Loy came to consider ANSTO's application for a licence to construct a new reactor, the plan to co-locate an LLILW store with a low-level repository had been abandoned by the federal government, and no alternative plan had been put in place.

Nevertheless Dr. Loy breached ARPANSA's previous commitment by granting a reactor construction licence even though no progress had been made towards establishing a LLILW store. ARPANSA had stated: "A licence to operate the reactor would not be issued by ARPANSA without there being clear and definite means available for the ultimate disposal of radioactive waste and spent nuclear fuel."[545]

Then the saga repeated itself with the reactor operating licence process.

- Dr. Loy said he would need to see "really clear progress" towards a LLILW store before issuing a reactor operating licence, "... my view is now that I wouldn't issue such a licence if there weren't substantial progress toward the store".[546]
- "I certainly don't want to leave it until 2015 before a store exists, and I think it's important as far as my licensing of the replacement reactor is concerned, that at the time we come to considering the license for its operation, I can be convinced that there will be a store. Not that it's in existence, but the processes are sufficiently proceeding, and are leading to a result that will convince me that there will be a store at the time it's needed."[547]
- "You don't necessarily have to have every loose end tied at the time of the operation license, but I have to be convinced that there will be a store."[548]
- "The issue of the long term storage of the intermediate level waste arising from the processing of spent fuel is also debated. The Government is proceeding with the planning for a national intermediate level waste store – there is political controversy about this as illustrated by the passage of legislation in South Australia to prevent the store being sited in that State. I expect that political controversy to continue, but with careful discussion and consultation with potential communities that may host the store I have no reason to believe that one will not be established within the time scale required for management of the returning waste from the RRR [replacement research reactor], noting that the first waste would not be expected to be returned to Australia until the mid 2020s. Nonetheless, I am expecting that the matter will be pursued vigorously and that there will be significant progress by the time any licence to operate the RRR is sought. I will be writing to the Minister for Science advising him of this expectation."[549]

Yet the reactor operating licence was issued by ARPANSA despite the absence of waste storage or disposal facilities. The plan to establish a low-level waste repository and LLILW store in SA was abandoned in 2004. The plan to establish a low-level waste repository and LLILW store in the NT was abandoned in 2014. As of July 2015, a revised process to establish a waste repository and LLILW store, based on assessment of volunteered sites, is in its early phases.

The lesson should be clear. Facilities generating radioactive waste should not be built (or licensed) unless waste disposal facilities are in place. Alternatively, storage sites should be established (and licensed), with firm plans for ultimate waste disposal in place − and a firm site.

Australian National Audit Office report

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[545] September 1999, Safety Evaluation Report of ARPANSA's Regulatory Branch.
[546] ABC Radio National, Breakfast, 8 Aug 2002.
[547] ABC Radio National, PM, 13 Sept 2002.
[548] ABC Radio National, PM, 13 Sept 2002.
[549] Statement by the CEO of ARPANSA, Dr John Loy – Licence to construct the Replacement Research Reactor, 5 April 2002.

The 2005 Australian National Audit Office report was critical of ARPANSA.[550] It said:

- The Regulatory Branch's operational objectives and activities are numerous, vary considerably in scope, are not prioritised, and are insufficiently specific to be clear or assessable.
- [O]verall management of conflict of interest is not sufficient to meet the requirements of the ARPANS Act and Regulations. ... Potential areas of conflict of interest are not explicitly addressed or transparently managed.
- The bulk of license assessments − some 75 per cent − were made without the support of robust, documented procedures.
- ARPANSA does not monitor or assess the extent to which licensees meet reporting requirements. The ANAO found that there had been under-reporting by licence holders.
- ARPANSA has reported only one designated breach to Parliament. This is notwithstanding that there have been a number of instances where ARPANSA has detected non-compliance by licensees.

The Australian National Audit Office's overall conclusions were as follows:
The ANAO concluded that improvements are required in the management of ARPANSA's regulatory function. While initial under-resourcing impacted adversely on regulatory performance, ARPANSA's systems and procedures are still not sufficiently mature to adequately support the cost-effective delivery of regulatory responsibilities.
In particular, deficiencies in planning, risk management and performance management limit ARPANSA's ability to align its regulatory operations with risks, and to assess its regulatory effectiveness.
As well, procedures for licensing and monitoring of compliance have not been sufficient, particularly as a licence continues in force until it is cancelled or surrendered. Current arrangements do not adequately support the setting of fees in a user-pays environment, nor ARPANSA's responsibilities for transparently managing the potential for conflict of interest.

ARPANSA − ANSTO saga

Since 2007 ARPANSA has been drawn into an unseemly process regarding incidents and accidents at ANSTO's Lucas Heights site and its treatment of whistleblowers. ARPANSA issued two contradictory reports on the issue, leading the Minister to establish an inquiry into ARPANSA. amid with questions about ARPANSA's independence The ABC reported in July 2011:
"The Health Department's audit and fraud control branch has been investigating how ARPANSA handled allegations of safety breaches and bullying at the nation's only nuclear reactor in Sydney. Whistleblowers had alleged ARPANSA was too close to the Australian Nuclear Science and Technology Organisation (ANSTO), which runs the Lucas Heights research facility. The whistleblowers claimed that safety reports were being compromised. The Health Department review also questioned ARPANSA's impartiality."[551]

In 2011, the then Parliamentary Secretary for Health and Ageing, Catherine King, announced a review into ARPANSA's regulatory powers following the receipt of an independent audit by the Audit and Fraud Control Branch of the Department of Health and Ageing into ARPANSA's handing of two safety incidents at ANSTO in September 2007 and August 2008. The audit found that while the incidents were investigated and concluded at the time, there was a lack of consistency in evidence and transparency in the handling of one of the incidents.[552]

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[550] www.foe.org.au/sites/default/files/Audit%20Office%20-%20ARPANSA.pdf
[551] www.abc.net.au/news/stories/2011/07/07/3264086.htm
See also: www.abc.net.au/news/stories/2011/03/30/3178186.htm
See also: www.foe.org.au/ansto-whistleblower-saga-2007-ongoing
[552] Catherine King, 7 July 2011, Media Release: 'Review of Regulatory Powers of the Australian Radiation Protection and Nuclear Safety Agency'.

The ABC reported:[553]
Australia's nuclear industry regulator, ARPANSA, is under review over its handling of safety breaches at the nation's only nuclear reactor. Last year, ABC 1's Lateline revealed allegations of serious safety and operational breaches at the Lucas Height's reactor in Sydney, which were later backed up by Australia's workplace regulator, Comcare. A departmental investigation was launched by Science Minister Kim Carr last month, but now a party to that investigation - ARPANSA - is itself under review. The Chief Auditor is investigating how ARPANSA handled the original allegations of safety breaches and bullying at the nuclear site. ARPANSA last year released two conflicting reports on the claims at the Lucas Heights facility.

Questions regarding ARPANSA

The NFCRC may wish to seek answers to the following questions.

The relevant Minister is empowered by the ARPANS Act to override decisions made by the CEO of ARPANSA. Is that appropriate, and are there similar provisions in legislation in other comparable countries?

Is it (still) the case that Section 83 of the ARPANS Act allows for a law of a State or Territory to be prescribed such that it does not apply to the activities of controlled persons under the Act? In other words, the ARPANS Act can be used to override state/territory legislation prohibiting legislation, such as state legislation prohibiting the establishment of a radioactive waste repository or store?

What size workforce would be required to oversee a nuclear power program in Australia? To what extent could additional regulatory staff be recruited from overseas? Would educational / training facilities be required in Australia; and if so at what cost, and who would bear that cost?

How might problems overseas − such as the ageing of the nuclear workforce and the nuclear regulatory workforce − impact on efforts to establish a suitable regulatory infrastructure for nuclear power in Australia?

3.11 How might a comparison of the emission of greenhouse gases from generating electricity in South Australia from nuclear fuels as opposed to other sources be quantified, assessed or modelled? What information, including that drawn from relevant operational experience should be used in that comparative assessment? What general considerations are relevant in conducting those assessments or developing these models?

Summary

First, a summary of key issues regarding nuclear power and climate change:
Nuclear Power is Not a Silver Bullet
Nuclear power could at most make a modest contribution to climate change abatement. The main limitation is that it is used almost exclusively for electricity generation, which accounts for less than 25% of global greenhouse emissions. Even tripling nuclear power generation would reduce emissions by less than 10% − and then only if the assumption is that it displaces coal.
Greenhouse Emissions from the Nuclear Fuel Cycle

[553] ABC, 30 March 2011, 'Nuclear regulator investigated over safety review', www.abc.net.au/news/stories/2011/03/30/3178186.htm
See also: www.emfacts.com/2011/07/arpansa-being-investigated-for-improper-relationship-with-nuclear-agency/
See also: ABC, 8 July 2011, 'Nuclear regulator 'too close' to ANSTO', www.abc.net.au/news/stories/2011/07/07/3264086.htm

Claims that nuclear power is 'greenhouse free' are false. Nuclear power is more greenhouse intensive than most renewable energy sources and energy efficiency measures. Life-cycle greenhouse emissions from nuclear power will increase as relatively high-grade uranium ores are mined out.

Nuclear Power – A Slow Response to an Urgent Problem

The nuclear industry does not have the capacity to rapidly expand production as a result of 20 years of stagnation. Limitations include bottlenecks in the reactor manufacturing sector, dwindling and ageing workforces, and the considerable time it takes to build a reactor and to pay back the energy debt from construction.

Nuclear Power *and* Climate Change

Countries and regions with a high reliance on nuclear power also tend to have high greenhouse gas emissions.

Some countries are planning to replace fossil fuel-fired power plants with nuclear power in order to increase fossil fuel exports − in such cases any potential climate change mitigation benefits of nuclear power are lost.

Climate Change and Nuclear Hazards

Nuclear power plants are vulnerable to threats which are being exacerbated by climate change. These include dwindling and warming water sources, sea-level rise, storm damage, drought, and jelly-fish swarms.

'Water wars' − in particular, disputes over the allocation of increasingly scarce water resources between power generation and agriculture − are becoming increasingly common and are being exacerbated by climate change

Weapons Proliferation and Nuclear Winter

Civil nuclear programs have provided cover for numerous covert weapons programs and an expansion of nuclear power would exacerbate the problem.

Nuclear warfare − even a limited nuclear war involving a tiny fraction of the global arsenal − has the potential to cause catastrophic climate change.

Renewables and Energy Efficiency

Global renewable power capacity more than doubled from 2004 to 2014 (and non-hydro renewables grew 8-fold). Over that decade, and the one before it, nuclear power flatlined.

Global renewable capacity (including hydro) is 4.6 times greater than nuclear capacity, and renewable electricity generation more than doubles nuclear generation. A growing body of research demonstrates the potential for renewables to largely supplant fossil fuels for power supply globally.

Energy efficiency and renewables are the Twin Pillars of a clean energy future. A University of Cambridge study[554] *concluded that 73% of global energy use could be saved by energy efficiency and conservation measures − making it far easier to achieve a low-carbon, non-nuclear future.*

Life-cycle greenhouse emissions

There have been many studies attempting to quantify life-cycle greenhouse emissions from different energy/power sources. Academic Benjamin Sovacool screened 103 lifecycle studies of greenhouse emissions from the nuclear fuel cycle to identify the most current, original, and transparent studies.[555] He found that the mean value from those studies was 66 grams of carbon dioxide equivalent per kilowatt-hour (gCO2e/kWh).

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[554] Jonathan M. Cullen, Julian M. Allwood, and Edward H. Borgstein, Jan 2011, 'Reducing Energy Demand: What Are the Practical Limits?', *Environmental Science and Technology*, 45 (4), pp 1711–1718, http://pubs.acs.org/doi/abs/10.1021/es102641n

[555] Benjamin K. Sovacool, Aug 2008, 'Valuing the Greenhouse Gas Emissions from Nuclear Power: A Critical Survey', *Energy Policy* 36 (8), pp.2940-2953, www.sciencedirect.com/science/article/pii/S0301421508001997 www.nirs.org/climate/background/sovacool_nuclear_ghg.pdf

Sovacool's paper provides the following figures (gCO2e/kWh):

Wind	9−10
Hydro	10−13
Biogas	11
Solar thermal	13
Biomass	14−31
Solar PV	32
Biomass	35−41
Geothermal	38
Nuclear	66
Natural gas	443
Diesel	778
Heavy oil	778
Coal	960−1050

Sovacool states:
"Offshore wind power has less than one-seventh the carbon equivalent emissions of nuclear plants; large-scale hydropower, onshore wind, and biogas, about one-sixth the emissions; small-scale hydroelectric and solar thermal one-fifth. This makes these renewable energy technologies seven-, six-, and five-times more effective on a per kWh basis at fighting climate change. Policymakers would be wise to embrace these more environmentally friendly technologies if they are serious about producing electricity and mitigating climate change."[556]

In a 2009 paper prepared for the Australian Uranium Association, academic Manfred Lenzen concluded that life-cycle greenhouse emissions for nuclear power range from 10−130 gCO2e/kWh with the main variables being ore grades, enrichment technology, reactor fuel re-load frequency and burn-up, and to a lesser extent enrichment level, plant lifetime, load factors, and enrichment tails assay. Lenzen calculates a "worst case" – 0.01% ore grade, 75% load factor, 25 year lifetime, only diffusion enrichment, and a carbon-intensive background economy – resulting in emissions of 248 gCO2e/kWh.[557]

Others calculate still higher values, for example by assuming energy- and emissions-intensive burial of large volumes of low-level ore, waste rock, and mill tailings, rather than the current practice of surface storage.

Life-cycle greenhouse emissions from nuclear power will increase as relatively high-grade uranium ores are mined out. In 2009, mining consultancy firm CRU Group calculated that the average grade of uranium projects at the feasibility study stage around the world was 35% lower than the grades of operating mines, and that exploration projects had average grades 60% below existing operations.[558]

The extent of the increase in the greenhouse intensity of uranium mining is the subject of debate and considerable uncertainty. It depends not only on declining ore grades but also on other variables such as the choice of tailings management options at uranium mines.

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[556] Benjamin K. Sovacool, 11 Dec 2009, 'Nuclear Energy and Renewable Power: Which is the Best Climate Change Mitigation Option', Nuclear Monitor #699, www.wiseinternational.org/sites/default/files/images/NM699.pdf
[557] Manfred Lenzen, 2009, 'Current state of development of electricity-generating technologies – a literature review', http://web.archive.org/web/20140124203606/http://aua.org.au/Content/Lenzenreport.aspx
[558] CRU Group, 2009, 'Next generation uranium – at what cost?', http://web.archive.org/web/20101121115919/http://crugroup.com/Documents/UraniumPressRelease2009Sep23.pdf

Writing in the *Journal of Industrial Ecology* in 2012, Warner and Heath stated that emissions from the nuclear fuel cycle could increase by 55−220% with declining uranium ore grades.[559]

Academic Dr Mark Diesendorf states: "In the case where high-grade uranium ore is used, CO2 emissions from the nuclear fuel cycle are much less than those of an equivalent gas-fired power station. But the world's reserves of high-grade uranium are very limited and may only last a few decades. The vast majority of the world's uranium is low-grade. CO2 emissions from mining, milling and enrichment of low-grade uranium are substantial, and so total CO2 emissions from the nuclear fuel cycle become greater than or equal to those of a gas-fired power station."[560]

Keith Barnham, Emeritus Professor of Physics at Imperial College London, states that for ore with uranium concentration around 0.01%, the carbon footprint of nuclear electricity could be as high as that of electricity generation from natural gas.[561]

The German Environment Ministry stated in a 2006 report that a modern gas-fired power station in connection with heat production (co-generation) could be less carbon intensive than nuclear power.[562]

Some nuclear lobbyists claim that Generation IV fast neutron reactors would reduce emissions from the nuclear fuel cycle by using waste products (esp. depleted uranium and spent fuel) as fuel instead of mined uranium. One of the problems with that argument is that Generation IV reactors are − and always have been − decades away (see 3.2 above). As for the real-world experience with fast neutron reactors, for the most part they have failed every test including carbon intensity. White elephants such as Japan's Monju reactor and France's Superphenix produced so little electricity that the carbon intensity must have been high. Monju operated for 205 days after it was connected to the grid in August 1995, and a further 45 days in 2010 − apart from that it has been shut-down because of a sodium leak and fire in 1996, and a 2010 accident when a 3.3 tonne refuelling machine fell into the reactor vessel.[563] The lifetime load factor of the French Superphenix fast reactor − the ratio of electricity generated compared to the amount that would have been generated if operated continually at full capacity − was just 7% percent, making it one of the worst-performing reactors in history.[564]

Nuclear power is not a silver bullet

Nuclear power could at most make a modest contribution to climate change abatement. The main limitation is that it is used almost exclusively for electricity generation, which accounts for less than 25% of global greenhouse emissions.[565]

The Switkowski Review stated that the construction of 12 power reactors from 2025−2050 would reduce Australia's greenhouse emissions by 8% relative to business as usual, assuming that nuclear power

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[559] Ethan S. Warner and Garvin A. Heath, April 2012, 'Life Cycle Greenhouse Gas Emissions of Nuclear Electricity Generation: Systematic Review and Harmonization', *Journal of Industrial Ecology*, Vol. 16, Issue Supplement s1, pp.S73–S92, http://onlinelibrary.wiley.com/doi/10.1111/j.1530-9290.2012.00472.x/full

[560] Mark Diesendorf, 2005, ABC 'Ask an Expert', www.abc.net.au/science/expert/realexpert/nuclearpower/03.htm

[561] Keith Barnham, 5 Feb 2015, 'False solution: Nuclear power is not 'low carbon'' www.theecologist.org/News/news_analysis/2736691/false_solution_nuclear_power_is_not_low_carbon.html

[562] German Environment Ministry, March 2006, 'Atomkraft: Ein teurer Irrweg. Die Mythen der Atomwirtschaft'.

[563] www.world-nuclear.org/info/Country-Profiles/Countries-G-N/Japan/ https://en.wikipedia.org/wiki/Monju_Nuclear_Power_Plant#Monju_sodium_leak_and_fire

[564] Mycle Schneider, 2009, 'Fast Breeder Reactors in France', *Science and Global Security*, 17:36–53, www.princeton.edu/sgs/publications/sgs/archive/17-1-Schneider-FBR-France.pdf

[565] Electricity plus heat account for 25% of emissions. See IPCC, 2014: Summary for Policymakers. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the IPCC, p.9, www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_summary-for-policymakers.pdf

displaces coal.[566] Emissions savings would be lower if the assumption is that nuclear power displaces gas.

Globally:

- Doubling current nuclear capacity would reduce emissions by roughly 6% if nuclear displaced coal[567] − or not at all if nuclear displaced renewables and energy efficiency.
- A 2007 report by the International Panel on Fissile Materials (IPFM) states that if nuclear power grew approximately three-fold to about 1000 GWe in 2050, the increase in global greenhouse emissions projected in business-as-usual scenarios could be reduced by about 10−20% − assuming that nuclear displaced coal.[568]
- According to a 2007 article in *Progress in Nuclear Energy*, a ten-fold increase in nuclear capacity by the end of the century would reduce greenhouse emissions by 15% percent.[569]

Nuclear vs. renewables

Greenhouse emissions from renewable energy sources vary but are typically similar to nuclear power.[570] If nuclear power displaces those renewable energy sources that are less greenhouse intensive than nuclear power and/or the many energy efficiency measures which are less greenhouse intensive than nuclear power, nuclear power will result in increased greenhouse emissions. Global renewable energy capacity – mostly hydroelectricity – already exceeds nuclear capacity. Renewable energy sources can also be deployed more rapidly than nuclear power.

Energy efficiency measures are capable of generating large reductions in greenhouse emissions and can do so more cheaply and quickly than installing nuclear power – therefore, investing in nuclear power instead of energy efficiency measures exacerbates and accelerates climate change.

Nuclear power is impractical as a short-term response

Expanding nuclear power is impractical as a short-term response to the need to urgently reduce greenhouse emissions. The industry does not have the capacity to rapidly expand production as a result of over 20 years of stagnation. Limitations include bottlenecks in the reactor manufacturing sector, the ageing workforce (a 'silver tsunami'), and the considerable time it takes to build a reactor and to pay back the energy debt from construction.

One constraint is the considerable time it takes to build reactors. The World Nuclear Industry Status Report 2014 noted that the average construction time of the last 37 reactors that started up was 10 years;

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[566] Switkowski Review, 2006, 'Uranium Mining, Processing and Nuclear Energy Review', http://pandora.nla.gov.au/tep/66043

[567] The basis for the calculation is as follows: Ian Hore-Lacey from the World Nuclear Association claims that doubling nuclear power would reduce greenhouse emissions from the power sector by 25%, and the power sector accounts for less than 25% of total emissions. Ian Hore-Lacy, 4 May 2006, 'Nuclear wagon gathers steam', *Courier Mail*.

[568] International Panel on Fissile Materials, 2007, 'Global Fissile Material Report 2007', Chapter 7, http://fissilematerials.org/library/gfmr07.pdf

[569] Tae Joon Lee, Kyung Hee Lee, and Keun-Bae Oh, 'Strategic Environments for Nuclear Energy Innovation in the Next Half Century', *Progress in Nuclear Energy*, Vol. 49 (2007), p.399 (pp.397−408), www.sciencedirect.com/science/article/pii/S0149197007000467.
Cited in Moeed Yusuf, Nov 2008, 'Does Nuclear Energy Have a Future', Boston University, fn.54, www.bu.edu/pardee/files/documents/Pardee-Nuclear-Yusuf.pdf

[570] Switkowski Review, 2006, 'Uranium Mining, Processing and Nuclear Energy Review', p.93, http://pandora.nla.gov.au/tep/66043

and that at least 49 of the 67 reactors listed as under construction have encountered construction delays.[571]

Another constraint is bottlenecks in the reactor manufacturing sector. Sharon Squassoni noted in a 2009 paper:
"A significant expansion will narrow bottlenecks in the global supply chain, which today include ultra-heavy forgings, large manufactured components, engineering, and craft and skilled construction labor. All these constraints are exacerbated by the lack of recent experience in construction and by aging labor forces. Though these may not present problems for limited growth, they will certainly present problems for doubling or tripling reactor capacity."[572]

Another constraint is the pattern of ageing nuclear workforces − the 'silver tsunami'.[573] In the UK, for example, a recent government report says that attrition rates in the ageing nuclear workforce are "high and growing" with more than 8,000 new employees a year needed every year for the next six years if the country's ambitious new-build programme is to succeed.[574] In addition, research and training facilities and courses have been on the decline.

The development of new reactor types − even those which are just modified versions of conventional reactor technology − further delays the construction and deployment of nuclear power. For example the EPR in Finland is 7−9 years behind schedule, and the EPR in France is five years behind schedule (and counting).[575]

Nuclear power deployment is slower still for countries building their first reactor. The IAEA sets out a phased 'milestone' approach to establishing nuclear power in new countries. This lasts from 11−20 years and includes a pre-project phase 1 (1−3 years), a project decision-making phase (3−7 years) and a construction phase (7−10 years).[576]

The French Nuclear Safety Authority (ASN) says that the initial development of a nuclear power industry requires at least 10−15 years in order to build up skills in safety and control and to develop a regulatory framework − that is 10−15 years even before reactor construction begins. Even with rapid progress, ASN estimates a minimum lead time of 15 years before a new nuclear power plant can be started up in a country that does not already have the required infrastructure.[24]

Prof. Ian Lowe notes:
"The Switkowski report says at least 10 and possibly 15 years would be a realistic time scale for building one nuclear power station in Australia. It would take more time still to "pay back" the energy used in construction and fuelling, so it would take 15 to 20 years for any such station to make any contribution to cutting greenhouse pollution. Fifteen to 20 months is a more realistic time scale for

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[571] World Nuclear Industry Status Report 2014, www.worldnuclearreport.org/-2014-.html
[572] Sharon Squassoni, 2009, 'Nuclear Energy: Rebirth or Resuscitation?', Carnegie Endowment Report, http://carnegieendowment.org/files/nuclear_energy_rebirth_resuscitation.pdf
[573] Sylvia Westall, 29 Nov 2010, 'Nuclear's 'silver tsunami", www.reuters.com/article/2010/11/29/us-nuclear-ageing-idUSTRE6AS1PQ20101129
[574] HM Government, 2015, 'Sustaining Our Nuclear Skills, www.nsan.co.uk/system/files/Sustaining%20Our%20Nuclear%20Skills%20FINAL.pdf
[575] Jim Green and Oliver Tickell, 15 May 2015, 'Finland cancels Olkiluoto 4 nuclear reactor - is the EPR finished?', *The Ecologist*, www.theecologist.org/News/news_analysis/2859924/finland_cancels_olkiluoto_4_nuclear_reactor_is_the_epr_finished.html
[576] World Nuclear Association, June 2015, 'Emerging Nuclear Energy Countries', world-nuclear.org/info/Country-Profiles/Others/Emerging-Nuclear-Energy-Countries/

large-scale renewables. Global warming is an urgent problem that demands a concerted response now, not a half-baked response after 2020."[577]

In addition to reactor construction, further years elapse before nuclear power has generated as much as energy as was expended in the construction of the reactor. One academic report states: "The energy payback time of nuclear energy is around 6½ years for light water reactors, and 7 years for heavy water reactors, ranging within 5.6–14.1 years, and 6.4–12.4 years, respectively."[578]

By contrast, construction times for renewable energy sources are typically months not years, and likewise the energy pay-back period is typically months not years.

Nuclear winter

As well as being a limited response to climate change, nuclear power is a highly problematic response, not least because of the links between the 'peaceful atom' and weapons proliferation. Any expansion of nuclear power is likely to exacerbate the problem. Doubling nuclear output by the middle of the century would require the construction of approximately 800 reactors to replace most of the existing cohort of reactors and to build as many again. Those reactors would produce enough plutonium to build over one million nuclear weapons. Since most power reactors use enriched uranium fuel, further proliferation risks would arise from enrichment plants.

A much larger expansion of nuclear power would have a greater impact on greenhouse emissions to the extent that it displaced fossil fuels. But the weapons proliferation risks would also grow.

A 2007 report by the International Panel on Fissile Materials (IPFM) states:[579]
Even a modest expansion of nuclear power would be accompanied by a substantial increase in the number of countries with nuclear reactors. Some of these countries would likely seek gas-centrifuge uranium-enrichment plants as well. Centrifuge-enrichment plants can be quickly converted to the production of highly enriched uranium for weapons. It is therefore critical to find multinational alternatives to the proliferation of national enrichment plants.
If a large-scale expansion of nuclear power were accompanied by a shift to reprocessing and plutonium recycle in light-water or fast reactors, it would involve annual flows of separated plutonium on the scale of a thousand metric tons per year − enough for 100,000 nuclear bombs.

Dr Mark Diesendorf from the University of NSW states:
"On top of the perennial challenges of global poverty and injustice, the two biggest threats facing human civilisation in the 21st century are climate change and nuclear war. It would be absurd to respond to one by increasing the risks of the other. Yet that is what nuclear power does."[580]

Likewise, former US Vice President Al Gore said:
"For eight years in the White House, every weapons-proliferation problem we dealt with was connected to a civilian reactor program. And if we ever got to the point where we wanted to use nuclear reactors to

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[577] Ian Lowe, 7 Sept 7, 2007, 'Heeding the warning signs', *Sydney Morning Herald*, www.smh.com.au/news/national/heeding-the-warning-signs/2007/09/06/1188783415604.html
[578] University of Sydney / Integrated Sustainability Analysis, 2006, '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, http://pandora.nla.gov.au/pan/66043/20061201-0000/www.dpmc.gov.au/umpner/docs/commissioned/ISA_report.pdf
[579] International Panel on Fissile Materials, 2007, 'Global Fissile Material Report 2007', Chapter 7, http://fissilematerials.org/library/gfmr07.pdf
[580] Mark Diesendorf, 14 Oct 2009, 'Need energy? Forget nuclear and go natural', www.theage.com.au/opinion/society-and-culture/need-energy-forget-nuclear-and-go-natural-20091014-gvzo.html)

back out a lot of coal ... then we'd have to put them in so many places we'd run that proliferation risk right off the reasonability scale."[581]

Running the proliferation risk off the reasonability scale brings the debate back to climate change − a connection explained by Alan Robock in *The Bulletin of the Atomic Scientists*:
"As recent work ... has shown, we now understand that the atmospheric effects of a nuclear war would last for at least a decade − more than proving the nuclear winter theory of the 1980s correct. By our calculations, a regional nuclear war between India and Pakistan using less than 0.3% of the current global arsenal would produce climate change unprecedented in recorded human history and global ozone depletion equal in size to the current hole in the ozone, only spread out globally."[582]

Climate change and nuclear hazards

Nuclear power plants are vulnerable to threats which are being exacerbated by climate change − discussed in detail in Nuclear Monitor #770.[583]

A 2013 report by the US Department of Energy details many of the interconnections between climate change and energy.[584] These include:
- Increasing risk of shutdowns at thermoelectric power plants (e.g. coal, gas and nuclear) due to decreased water availability which affects cooling, a requirement for operation;
- Higher risks to energy infrastructure located along the coasts due to sea level rise, the increasing intensity of storms, and higher storm surge and flooding;
- Disruption of fuel supplies during severe storms;
- Power plant disruptions due to drought; and
- Power lines, transformers and electricity distribution systems face increasing risks of physical damage from the hurricanes, storms and wildfires that are growing more frequent and intense.

At the lower end of the risk spectrum, there are many instances of nuclear plants operating at reduced power or being temporarily shut down due to water shortages or increased water temperature (which can adversely affect reactor cooling and/or cause fish deaths and other problems with the dumping of waste heat in water sources). Reactors in several countries have been forced to close during heat waves, when they're needed the most. For example, France had to purchase power from the UK in 2009 because almost a third of its nuclear generating capacity was lost when it had to cut production to avoid exceeding thermal discharge limits.[585]

At the upper end of the risk spectrum, climate-related threats pose serious risks such as storms cutting off grid power, leaving nuclear plants reliant on generators for reactor cooling. A 2004 incident in Germany illustrates the risks. Both Biblis reactors (A and B) were in operation when heavy storms knocked out power lines. Because of an incorrectly set electrical switch and a faulty pressure gauge, the Biblis-B turbine did not drop, as designed, from 1,300 to 60 megawatts. Instead the reactor scrammed. When Biblis-B scrammed with its grid power supply already cut off, four emergency diesel generators started. Another emergency supply also started but, because of a switching failure, one of the lines failed

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[581] Quoted in David Roberts, 9 May 2006, 'An interview with accidental movie star Al Gore', http://grist.org/article/roberts2/
[582] Alan Robock, 14 Aug 2008, 'We should really worry about nuclear winter', *The Bulletin of the Atomic Scientists*, http://thebulletin.org/has-time-come-geoengineering/we-should-really-worry-about-nuclear-winter
[583] Nuclear Monitor #770, 24 Oct 2013, 'Feature: Water & The Nuclear Fuel Cycle', www.wiseinternational.org/nuclear-monitor/770/770-24-october-2013
[584] Department of Energy, July 2013, 'U.S. Energy Sector Vulnerabilities to Climate Change and Extreme Weather', http://energy.gov/downloads/us-energy-sector-vulnerabilities-climate-change-and-extreme-weather
[585] Robert Krier, 15 Aug 2012, 'Extreme Heat, Drought Show Vulnerability of Nuclear Power Plants', *InsideClimate News*, http://insideclimatenews.org/news/20120815/nuclear-power-plants-energy-nrc-drought-weather-heat-water

to connect. These lines would have been relied upon as a backup to bring emergency power from Biblis-B to Biblis-A if Biblis-A had also been without power. The result was a partial disabling of the emergency power supply from Biblis-B to Biblis-A for about two hours.[586]

'Water wars' will become increasingly common with climate change − in particular, disputes over the allocation of increasingly scarce water resources between power generation and agriculture. Nuclear power reactors consume massive amounts of water − typically 36.3 to 65.4 million litres per reactor per day − primarily for reactor cooling.[587]

Jellyfish swarms have caused problems at many nuclear plants around the world.[588] Increased fishing of jellyfish predators and global warming are contributing to higher jellyfish populations. Monty Graham, co-author of a study on jellyfish blooms published in the *Proceedings of the National Academy of Sciences*, blames global warming, overfishing, and the nitrification of oceans through fertiliser run-off.[589]

The Union of Concerned Scientists argued in a 2013 report:
"Low-carbon power is not necessarily water-smart. Electricity mixes that emphasise carbon capture and storage for coal plants, nuclear energy, or even water-cooled renewables such as some geothermal, biomass, or concentrating solar could worsen rather than lessen the sector's effects on water. That said, renewables and energy efficiency can be a winning combination. This scenario would be most effective in reducing carbon emissions, pressure on water resources, and electricity bills. Energy efficiency efforts could more than meet growth in demand for electricity in the US, and renewable energy could supply 80% of the remaining demand."[590]

The REN21 'Renewables 2015: Global Status Report' states:[591]
"All energy systems are susceptible to climate variability and extremes. For example, decreasing water levels and droughts can lead to the shutdown of thermal power plants that depend on water-based cooling systems. Dry periods, alternating with floods, can shift erosion and deposition patterns, altering growth rates of biomass and affecting the quality and quantity of the potential fuel output. The melting of glaciers, induced by temperature increases, can have a negative effect on hydropower systems by causing infrastructure damage from flooding and siltation, as well as affecting generation capacity. The efficiency of solar PV declines with high temperatures and dust accumulation, and most of today's wind turbines shut down in winds exceeding 100 to 120 kilometres per hour.
Typical responses to reducing system vulnerability involve reinforcing existing infrastructure (including strengthening transmission towers and lines); ensuring redundancy of critical systems; building seawalls around power plants; reducing the need for power plant cooling water; and storing larger quantities of fuel at plants. More innovative strategies include local generation and storage, diversification of energy sources, use of a combination of smart grids and technologies, and improving capabilities to couple and decouple individual systems from the central grid system during emergencies.

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[586] Helmut Hirsch, Oda Becker, Mycle Schneider and Antony Froggatt, April 2005, 'Nuclear Reactor Hazards: Ongoing Dangers of Operating Nuclear Technology in the 21st Century', Report prepared for Greenpeace International, www.greenpeace.org/international/press/reports/nuclearreactorhazards
[587] 'How much water does a nuclear power plant consume?', Nuclear Monitor #770, 24 Oct 2013, www.wiseinternational.org/nuclear-monitor/770/how-much-water-does-nuclear-power-plant-consume
[588] www.wiseinternational.org/nuclear-monitor/770/jellyfish-shut-down-swedish-nuclear-plant
[589] Glenda Kwek, 11 July 2011, 'Jellyfish force shutdown of power plants', www.theage.com.au/environment/jellyfish-force-shutdown-of-power-plants-20110711-1haa6.html
[590] Union of Concerned Scientists, July 2013, 'Water-Smart Power: Strengthening the U.S. Electricity System in a Warming World', www.ucsusa.org/our-work/energy/our-energy-choices/our-energy-choices-energy-and-water-use
[591] REN21 (Renewable Energy Policy Network for the 21st Century), 2015, 'Renewables 2015: Global Status Report', www.ren21.net/status-of-renewables/global-status-report

Although renewable energy systems are also vulnerable to climate change, they have unique qualities that make them suitable both for reinforcing the resilience of the wider energy infrastructure and for ensuring the provision of energy services under changing climatic conditions. System modularity, distributed deployment, and local availability and diversity of fuel sources − central components of energy system resilience − are key characteristics of most renewable energy systems. Ultimately, renewable energy systems improve the resilience of conventional power systems, both individually and by their collective contribution to a more diversified and distributed asset pool."

3.12 What are the wastes (other than greenhouse gases) produced in generating electricity from nuclear and other fuels and technologies? What is the evidence of the impacts of those wastes on the community and the environment? Is there any accepted means by which those impacts can be compared? Have such assessments making those comparisons been undertaken, and if so, what are the results? Can those results be adapted so as to be relevant to an analysis of the generation of electricity in South Australia?

Radioactive/nuclear waste issues are addressed in detail in section 4.

Comparisons of the waste streams from different power sources are few and far between, in part because of the risks are of a very different nature:

Fossil fuels:
- Greenhouse gases, and poisonous emissions resulting in morbidity and mortality

Nuclear power:
- Long term environmental and public health risks from very large volumes of uranium tailings waste
- Contaminated groundwater from in-situ leach uranium mining
- Large volumes of depleted uranium waste from enrichment plants.
- Reactors produce high level radioactive waste in the form of spent nuclear fuel.
- Reprocessing plants generate a high level radioactive waste stream.
- Some waste streams have military potential. Depleted uranium is used in munitions. Spent nuclear fuel from reactors contains weapons-useable plutonium, and reprocessing (combined with limited plutonium use as reactor fuel) has resulted in a stockpile of 260 tonnes of separated plutonium.[592]

Renewables:
Waste streams from renewables vary greatly depending on the type of renewable energy under consideration. In general the waste streams are relatively benign compared to:
- the public health and environmental problems associated with poisonous emissions and greenhouse emissions from fossil fuel fired power plants; and
- the public health, environmental, proliferation and security problems associated with nuclear waste.

3.13 What risks for health and safety would be created by establishing facilities for the generation of electricity from nuclear fuels? What needs to be done to ensure that risks do not exceed safe levels?

The above questions are addressed under the following subheadings:
- History of accidents
- Safety of nuclear vs renewables
- Probabilistic risk assessments

[592] International Panel on Fissile Materials, www.fissilematerials.org

- Attacks on nuclear plants
- Childhood leukemias near nuclear power stations
- Australia's track record
- Counterfeit, fraudulent and suspect items

History of accidents

In a 2010 paper, academic Benjamin Sovacool documented 99 accidents at nuclear power plants from 1952 to 2009 that resulted in the loss of human life and/or more than US$50,000 of property damage. Of the 99 accidents, 57 occurred since the Chernobyl disaster in 1986, and 56 were in the USA, refuting the notion that severe accidents are relegated to the past or to countries without modern US technology and oversight.[593]

A 2015 study using the same criteria (loss of human life and/or more than US$50,000 of property damage) documents 174 accidents between 1946 and 2014 at nuclear power plants and associated facilities (uranium mines, enrichment plants, etc) and during transportation.[594] The authors note that statistical/empirical analyses of nuclear accidents have "almost universally" found that probabilistic risk assessment "dramatically underestimates the risk of accidents" (discussed further below).

The Los Alamos National Laboratory lists 60 criticality accidents − accidental nuclear chain reactions in fissile material such as enriched uranium or plutonium.[595] Of the 60 accidents, 38 occurred at research or experimental facilities such as research reactors, while 22 occurred in commercial nuclear facilities.

Safety challenges

Numerous safety challenges confront the industry, including the following:
- The ageing of the global nuclear workforce and the consequent loss of skills both for the operation of nuclear facilities and for regulatory bodies.
- Safety challenges will be greater in countries developing nuclear power for the first time, especially countries with a limited technical and industrial base, inadequate regulation, and/or widespread corruption.
- The 'bathtub effect' − a likely scenario in the coming 20 years is that an increasing majority of the global fleet of power reactors will be very young or very old, the two phases of a reactor's lifespan when they are most accident-prone.[596]
- Inadequate regulation in a number of countries, including advanced nuclear countries such as the US and Japan.
- The potential for commercial imperatives to reduce safety margins.
- Attacks on nuclear plants, whether by nation-states or sub-national groups (terrorists).

An MIT Interdisciplinary Study on the Future of Nuclear Power states:

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[593] Benjamin Sovacool, August 2010, 'A Critical Evaluation of Nuclear Power and Renewable Electricity in Asia', *Journal of Contemporary Asia*, Vol. 40, No. 3, pp.393–400.
See also Benjamin Sovacool, 2008, 'The costs of failure: A preliminary assessment of major energy accidents', *Energy Policy*, Vol. 36, pp.1802-1820.
[594] Spencer Wheatley, Benjamin Sovacool and Didier Sornette, April 2015, 'Of Disasters and Dragon Kings: A Statistical Analysis of Nuclear Power Incidents & Accidents', *Physics and Society*, http://arxiv.org/abs/1504.02380
[595] Monahan S, T McLaughlin, N Pruvost et al., 2000, 'A review of criticality accidents', Los Alamos National Laboratory, www.lanl.gov/news/index.php/fuseaction/home.story/story_id/1054. Direct download: www.orau.org/ptp/Library/accidents/la-13638.pdf
[596] David Lochbaum, 2004, 'U.S. Nuclear Plants in the 21st Century', Union of Concerned Scientists, www.ucsusa.org/assets/documents/nuclear_power/nuclear04fnl.pdf

"We do not believe there is a nuclear plant design that is totally risk free. In part, this is due to technical possibilities; in part due to workforce issues. Safe operation requires effective regulation, a management committed to safety, and a skilled work force."[597]

Serious, unresolved problems remain on all three fronts – regulation, management, and workforce skills and capacity. The safety culture varies considerably within and between nations operating nuclear power plants. As the MIT Study notes:
"It is still an open question whether the average performers in the industry have yet incorporated an effective safety culture into their conduct of business."

Regulatory problems include 'captured bureaucracies', the revolving door between regulatory bodies and regulated organisations, and shortages of skilled personnel to adequately carry out regulatory functions.

Safety of nuclear vs renewables

Claims that the safety of nuclear power is comparable to that of renewable energy sources do not stand up to scrutiny, for the following reasons (among others).

Firstly, and most importantly, nuclear power is the only energy source with multifaceted and repeatedly-demonstrated connections to the proliferation of Weapons of Mass Destruction. Moreover, there are serious proliferation-related security risks such as military attacks on nuclear plants to prevent their use in support of a weapons program (discussed below), and the interrelated problems of nuclear theft, smuggling and terrorism.

Secondly, claims that the safety of nuclear power is comparable to that of renewable energy sources ignore the long-term cancer death toll from major accidents, in particular Chernobyl and Fukushima. For Chernobyl, the World Health Organization estimates up to 9,000 excess cancer deaths in Belarus, the Russian Federation and Ukraine. Credible estimates of the Chernobyl cancer death toll across Europe range from 16,000[598] to 93,000[599]. For Fukushima, the long-term cancer death toll will be in the thousands. Based on UN data on human radiation exposure, UK radiation biologist Dr Ian Fairlie estimates around 5,000 fatal cancers from Fukushima fallout.[600]

Thirdly, claims that the safety of nuclear power is comparable to that of renewable energy sources ignore or downplay human radiation exposure from routine emissions from the nuclear fuel cycle. The United Nations Scientific Committee on the Effects of Atomic Radiation's estimated collective effective dose to the world population over a 50-year period of operation of nuclear power reactors and associated nuclear fuel cycle facilities is two million person-Sieverts.[601] Applying a risk estimate of 0.05−0.1 fatal cancers per person-Sievert gives a total of 100,000−200,000 fatal cancers.

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[597] Stephen Ansolabehere et al., 2003, 'The Future of Nuclear Power: An Interdisciplinary MIT Study', http://web.mit.edu/nuclearpower/pdf/nuclearpower-full.pdf
[598] E. Cardis, D. Krewski, et al, 2006, 'Estimates of the Cancer Burden in Europe from Radioactive Fallout from the Chernobyl', *International Journal of Cancer*, Volume 119, Issue 6, pp.1224-1235, www.ncbi.nlm.nih.gov/pubmed/16628547
[599] Greenpeace, 2006, 'The Chernobyl Catastrophe − Consequences on Human Health'. www.greenpeace.org/international/en/publications/reports/chernobylhealthreport/
[600] Ian Fairlie, 2 April 2014, 'New UNSCEAR Report on Fukushima: Collective Doses', www.ianfairlie.org/news/new-unscear-report-on-fukushima-collective-doses/
[601] United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), 1994, 'Ionising Radiation: Sources and Biological Effects', New York: UNSCEAR, www.unscear.org/unscear/en/publications/1994.html

Fourthly, non-fatal impacts must be considered. For example, the relocation of 350,000 people[602] in the aftermath of the Chernobyl disaster was associated with a great deal of trauma. Four years after the Fukushima disaster, around 80,000 people remain displaced specifically as a result of the nuclear accident. Using those figures (350,000 + 80,000), and the global experience of around 14,500 reactor-years of power reactor operations[603], gives a figure of approximately 30 'nuclear refugees' per reactor-year.

Probabilistic risk assessments

Physicist M.V. Ramana challenges "misleading" probabilistic risk assessments (PRA) such as Areva's estimate for its EPR of one core-damage incident per reactor in 1.6 million years, and Westinghouse's claims PDF that for its AP1000 reactors the core melt frequency is roughly one incident per reactor in two million years.[604]

Ramana writes:
"There are both empirical and theoretical reasons to doubt these numbers. A 2003 study on the future of nuclear power carried out by the Massachusetts Institute of Technology points out that "uncertainties in PRA methods and data bases make it prudent to keep actual historical risk experience in mind when making judgments about safety." What does history tell us? Globally, there have been close to 15,000 reactor-years of experience, with well-known severe accidents at five commercial power reactors -- three of them in Fukushima. However, as Thomas Cochran of the Natural Resources Defense Council explained in his recent testimony to the US Senate, depending on how core damage is defined, there are other accidents that should be included. The actuarial frequency of severe accidents may be as high as 1 in 1,400 reactor-years. At that rate, we can expect an accident involving core damage every 1.4 years if nuclear power expands from today's 440 commercial power reactors to the 1,000-reactor scenario laid out in the MIT study. In either case, though, our experience is too limited to make any reliable predictions."

Ramana notes that probabilistic risk assessment suffers from a number of problems and "any conclusions about overall accident probabilities derived from its use are far from dependable". He notes that before the Chernobyl accident, B.A. Semenov, the head of the International Atomic Energy Agency's safety division, said that "a serious loss-of-coolant accident is practically impossible" with Chernobyl-type reactors.

Attacks on nuclear plants

Historical examples of military strikes on nuclear plants include the following:
- Israel's destruction of a research reactor in Iraq in 1981.
- the United States' destruction of two smaller research reactors in Iraq in 1991.
- attempted military strikes by Iraq and Iran on each other's nuclear facilities during the 1980-88 war.
- Iraq's attempted missile strikes on Israel's nuclear facilities in 1991.
- Israel's bombing of a suspected nuclear plant in Syria in 2007.

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[602] WHO, 26 April 2006, 'World Health Organization report explains the health impacts of the world's worst-ever civil nuclear accident', www.who.int/mediacentre/news/releases/2006/pr20/en/
[603] World Nuclear Association, updated Feb 2015, 'Safety of Nuclear Power Reactors', www.world-nuclear.org/info/Safety-and-Security/Safety-of-Plants/Safety-of-Nuclear-Power-Reactors/
[604] M. V. Ramana, 19 April 2011, 'Beyond our imagination: Fukushima and the problem of assessing risk', *Bulletin of the Atomic Scientists*, http://thebulletin.org/web-edition/features/beyond-our-imagination-fukushima-and-the-problem-of-assessing-risk

Most of the above examples have been motivated by attempts to prevent weapons proliferation. Nuclear plants might also be targeted with the aim of widely dispersing radioactive material or, in the case of power reactors, disrupting electricity supply.

If and when nuclear-powered nations go to war, they will have to choose between shutting down their power reactors, or taking the risk of attacks potentially leading to widespread, large-scale dispersal of radioactive materials.

Nuclear physicist Richard Garwin poses these questions:[605]
What happens with a failed state with a nuclear power system? Can the reactors be maintained safely? Will the world (under the IAEA and U.N. Security Council) move to guard nuclear installations against theft of weapon-usable material or sabotage, in the midst of chaos? Not likely.

Even though Australia's nuclear industry is modest a comparable pattern of insecurity exists. Incidents at ANSTO's Lucas Heights site in southern Sydney include the following[606]:

- 1983: nine sticks of gelignite, 25 kg of ammonium nitrate (usable in explosives), three detonators and an igniter were found in an electrical substation inside the boundary fence. A detonator was set off but did not detonate the main explosives. Two people were charged.
- 1984: a threat was made to fly an aircraft packed with explosives into the HIFAR reactor − one person was found guilty of public mischief.
- 1985: after vandalism of a pipe, radioactive liquid drained into Woronora river, and this incident was not reported for 10 days. In 1986 an act of vandalism resulted in damage to the sampling pit on the effluent pipeline.
- 2000: in the lead-up to the Sydney Olympics, New Zealand detectives foiled a plot to attack the Lucas Heights reactor by Afghan sympathisers of Osama bin Laden.
- 9 October 2001: NSW and Federal police conducted a search following a bomb threat directed at ANSTO.
- December 2001: Greenpeace activists easily breach security at the front gate and the back fence of Lucas Heights, some activists scale the reactor while another breaches the 'secure air space' in a paraglider.
- October 2003: French terror suspect Willy Brigitte deported from Australia and held on suspicion of terrorism in France. He was alleged to have been planning to attack the reactor and to have passed on bomb-making skills to two Australians.
- November 2005: multiple coordinated arrests of terrorist suspects in Sydney and Melbourne. Court documents reveal the Lucas Heights reactor was a potential target. Three of the eight alleged members of the Sydney terror cell had previously been caught near the reactor facility by police in December 2004, each alleged to have given different versions of what they had been doing.
- November 2005: a reporter and photographer were able to park a one-tonne van for more than half an hour outside the Lucas Heights back gate, protected by a simple padlock able to be cut with bolt-cutters, 800 m from the reactor. *The Australian* reported: "The back door to one of the nation's prime terrorist targets is protected by a cheap padlock and a stern warning against trespassing or blocking the driveway."[607]

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[605] Richard L. Garwin, 2001, 'Can the World Do Without Nuclear Power?', www.solarpeace.ch/solarpeace/Download/20010409_Garwin_NuclearPowerArticle.pdf
[606] Tilman Ruff, 2006, 'Nuclear Terrorism', EnergyScience Coalition Briefing Paper #10, www.energyscience.org.au/FS10%20Nuclear%20Terrorism.pdf
[607] Jonathan Porter, 19 Nov 2005, 'Nuclear site left exposed at the back door', *The Australian*.

- A man facing terrorism charges in 2007 had purchased five rocket launchers allegedly stolen from the army. According to a witness statement, the accused purchaser said "I am going to blow up the nuclear place", an apparent reference to Lucas Heights.[608]

Childhood leukemia near nuclear power stations

Radiation biologist Dr. Ian Fairlie (among others) has written important articles about the links between childhood leukemias and nuclear power plants.

Fairlie notes that "world-wide, over 60 epidemiological studies have examined cancer incidences in children near nuclear power plants (NPPs): most (>70%) indicate leukemia increases."[609]

Data from four European countries reveal "a highly statistically significant 37% increase in childhood leukemias within 5 km of almost all NPPs in the UK, Germany, France and Switzerland. ... So the matter is now beyond question, i.e. there's a very clear association between increased child leukemias and proximity to NPPs. The remaining question is its cause(s)."[610]

Dr Fairlie's explanation is as follows: "First, the cancer increases may be due to radiation exposures from NPP emissions to air. Second, large annual spikes in NPP emissions may result in increased dose rates to populations within 5 km of NPPs. Third, the observed cancers may arise in utero in pregnant women. Fourth, both the doses and their risks to embryos and to fetuses may be greater than current estimates. And fifth, pre-natal blood-forming cells in bone marrow may be unusually radiosensitive."[611]

An article by Dr Fairlie is copied here. References to peer-reviewed literature are listed at: www.ianfairlie.org/publications/

> **Nuclear power stations cause childhood leukemia - and here's the proof**
> *Ian Fairlie*
> *23rd August 2014*
> *www.theecologist.org/News/news_analysis/2525488/nuclear_power_stations_cause_childhood_leukemia_and_heres_the_proof.html*
> I can think of no other area of toxicology (eg asbestos, lead, smoking) with so many studies, and with such clear associations as those between nuclear power plants and child leukemias.
> In March 2014, my article on increased rates of childhood leukemias near nuclear power plants (NPPs) was published in the *Journal of Environmental Radioactivity* (JENR).
> A previous post discussed the making of the article and its high readership: this post describes its content in layman's terms.
> Before we start, some background is necessary to grasp the new report's significance. Many readers may be unaware that increased childhood leukemias near NPPs have been a contentious issue for several decades.
> For example, it was a huge issue in the UK in the 1980s and early 1990s leading to several TV programmes, Government Commissions, Government committees, a major international

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[608] Sally Neighbour, 2 July 2007, 'Nations linked by blood and Islam', *The Australian*.
Charles Ferguson, 9 Jan 2007, 'Nuclear risk could be an inside job',
www.smh.com.au/news/opinion/nuclear-risk-could-be-an-inside-job/2007/01/08/1168104921045.html
[609] Ian Fairlie, 25 July 2014 'Childhood leukemias near nuclear power stations', www.ianfairlie.org/news/childhood-leukemias-near-nuclear-power-stations-new-article/
[610] Ian Fairlie, 25 July 2014 'Childhood leukemias near nuclear power stations', www.ianfairlie.org/news/childhood-leukemias-near-nuclear-power-stations-new-article/
[611] Ian Fairlie, 25 July 2014 'Childhood leukemias near nuclear power stations', www.ianfairlie.org/news/childhood-leukemias-near-nuclear-power-stations-new-article/

Conference, Government reports, at least two mammoth court cases and probably over a hundred scientific articles.
It was refuelled in 1990 by the publication of the famous Gardner report (Gardner et al, 1990) which found a very large increase (7 fold) in child leukemias near the infamous Sellafield nuclear facility in Cumbria.

Over 60 epidemiological studies confirm the link

The issue seems to have subsided in the UK, but it is still hotly debated in most other European countries, especially Germany.
The core issue is that, world-wide, over 60 epidemiological studies have examined cancer incidences in children near nuclear power plants (NPPs): most (>70%) indicate leukemia increases.
I can think of no other area of toxicology (eg asbestos, lead, smoking) with so many studies, and with such clear associations as those between NPPs and child leukemias.
Yet many nuclear Governments and the nuclear industry refute these findings and continue to resist their implications. It's similar to the situations with cigarette smoking in the 1960s and with man-made global warming nowadays.
In early 2009, the debate was partly rekindled by the renowned KiKK study (Kaatsch et al, 2008) commissioned by the German Government which found a 60% increase in total cancers and 120% increase in leukemias among children under 5 yrs old living within 5 km of all German NPPs.

What is 'statistically significant?

As a result of these surprising findings, governments in France, Switzerland and the UK hurriedly set up studies near their own NPPs. All found leukemia increases but because their numbers were small the increases lacked 'statistical significance'. That is, you couldn't be 95% sure the findings weren't chance ones.
This does *not* mean there were no increases, and indeed if less strict statistical tests had been applied, the results would have been 'statistically significant'.
But most people are easily bamboozled by statistics including scientists who should know better, and the strict 95% level tests were eagerly grasped by the governments wishing to avoid unwelcome findings. Indeed, many tests nowadays in this area use a 90% level.
In such situations, what you need to do is combine datasets in a meta-study to get larger numbers and thus reach higher levels of statistical significance.

Governments wouldn't do it - so we did

The four governments refrained from doing this because they knew what the answer would be, viz, statistically significant increases near almost all NPPs in the four countries.
So Korblein and Fairlie helped them out by doing it for them (Korblein and Fairlie, 2012), and sure enough there were statistically significant increases near all the NPPs. Here are their findings:

Table: Studies of observed (O) and expected (E) leukemia cases within 5 km of NPPs.

	O	E	SIR=O/E	90% CI	p-value
Germany	34	24.1	1.41	1.04-1.88	0.0328
Great Britain	20	15.4	1.30	0.86-1.89	0.1464
Switzerland	11	7.9 [a]	1.40	0.78-2.31	0.1711
France [b]	14	10.2	1.37	0.83-2.15	0.1506
Pooled data	**79**	**57.5**	**1.37**	**1.13 - 1.66**	**0.0042**

[a] derived from data in Spycher et al. (2011).
[b] acute leukemia cases

This table reveals a highly statistically significant 37% increase in childhood leukemias within 5 km of almost all NPPs in the UK, Germany, France and Switzerland.

It's perhaps not surprising that the latter 3 countries have announced nuclear phaseouts and withdrawals. It is only the UK government that remains in denial.
So the matter is now beyond question, ie there's a very clear association between increased child leukemias and proximity to NPPs. The remaining question is its cause(s).

Observed risk 10,000 times greater than it's meant to be

Most people worry about radioactive emissions and direct radiation from the NPPs, however any theory involving radiation has a major difficulty to overcome, and that is how to account for the large (~10,000 fold) discrepancy between official dose estimates from NPP emissions and the clearly-observed increased risks.
My explanation does involve radiation. It stems from KiKK's principal finding that the increased incidences of infant and child leukemias were closely associated with *proximity to the NPP chimneys*.
It also stems from KiKK's observation that the increased solid cancers were mostly *"embryonal"*, ie babies were born either with solid cancers or with pre-cancerous tissues which, after birth, developed into full-blown tumours: this actually happens with leukemia as well.
My explanation has five main elements:

- First, the cancer increases may be due to radiation exposures from NPP emissions to air.
- Second, large annual spikes in NPP emissions may result in increased dose rates to populations within 5 km of NPPs.
- Third, the observed cancers may arise *in utero* in pregnant women.
- Fourth, both the doses and their risks to embryos and to fetuses may be greater than current estimate.
- And fifth, pre-natal blood-forming cells in bone marrow may be unusually radiosensitive.

Together these five factors offer a possible explanation for the discrepancy between estimated radiation doses from NPP releases and the risks observed by the KIKK study. These factors are discussed in considerable detail in the full article.

No errors or omissions have been pointed out

My article in fact shows that the current discrepancy can be explained. The leukemia increases observed by KiKK and by many other studies may arise *in utero* as a result of embryonal / fetal exposures to incorporated radionuclides from NPP radioactive emissions.
Very large emission spikes from NPPs might produce a pre-leukemic clone, and after birth a second radiation hit might transform a few of these clones into full-blown leukemia cells.
The affected babies are born pre-leukemic (which is invisible) and the full leukemias are only diagnosed within the first few years after birth.
To date, no letters to the editor have been received pointing out errors or omissions in this article.
Dr Ian Fairlie is an independent consultant on radioactivity in the environment.
This article was originally published on Ian Fairlie's blog.

References

- Bithell JF, M F G Murphy, C A Stiller, E Toumpakari, T Vincent and R Wakeford. (2013) Leukaemia in young children in the vicinity of British nuclear power plants: a case-control study. Br J Cancer, advance online publication, September 12, 2013; doi:10.1038/bjc.2013.560.
- Bunch KJ, T J Vincent1, R J Black, M S Pearce, R J Q McNally, P A McKinney, L Parker, A W Craft and M F G Murphy (2014) Updated investigations of cancer excesses in individuals born or resident in the vicinity of Sellafield and Dounreay. British Journal of Cancer (2014), 1-10 | doi: 10.1038/bjc.2014.357
- Fairlie I (2013) A hypothesis to explain childhood cancers near nuclear power plants. Journal of Environmental Radioactivity 133 (2014) 10e17.

- Gardner MJ, Snee MP; Hall AJ; Powell CA; Downes S; Terrell JD (1990) Results of case-control study of leukaemia and lymphoma among young people near Sellafield nuclear plant in West Cumbria. BMJ. 1990;300:423-429.
- Kaatsch P, Spix C, Schulze-Rath R, Schmiedel S, Blettner M. (2008) Leukaemia in young children living in the vicinity of German nuclear power plants. Int J Cancer; 122: 721-726.
- Körblein A and Fairlie I (2012) French Geocap study confirms increased leukemia risks in young children near nuclear power plants. Int J Cancer 131: 2970-2971.
- Spycher BD, Feller M, Zwahlen M, Röösli M, von der Weid NX, Hengartner H, Egger M, Kuehni CE. 'Childhood cancer and nuclear power plants in Switzerland: A census based cohort study'. *International Journal of Epidemiology* (2011) doi:10.1093/ije/DYR115.

Issues on related topics raise further concerns, such as a UK government study which found a statistically significant link between childhood leukaemia and red-bone-marrow dose from gamma radiation:

> ***Radiation: association with childhood cancer***
> *https://www.gov.uk/government/publications/radiation-association-with-childhood-cancer*
> *From: Public Health England*
> *1 March 2013*
> *Part of: Radiation: HPA-CRCE scientific and technical report series*
> *This report (HPA-CRCE-045) is a record based case-control study to investigate associations between childhood cancer and natural background radiation in Great Britain.*
> ***Document***
> ***HPA-CRCE-045: report of a record-based case-control study of natural background radiation and incidence of childhood cancer in Great Britain***
> *Ref: ISBN 978-0-85951-730-0 PDF, 1.07MB, 131 pages*
> ***Detail***
> *Cases and matched controls came from the National Registry of Childhood Tumours. Cases were cancers registered for children born and diagnosed in Great Britain during 1980 to 2006. Radiation exposures were estimated for mother's residence at the child's birth from national databases, using the County-District mean for gamma-rays, and a predictive map for radon. Among 27 447 cancer cases and 36 793 controls there was 12% excess relative risk (95% CI 3, 22; 2- sided p=0.01) of childhood leukaemia per millisievert of red-bone-marrow dose from gamma radiation; the association with radon was not significant. Associations for other childhood cancers were not significant for any radiation type. Excess risk was insensitive to alternative adjustments for socio-economic status.*
> *The statistically significant leukaemia risk reported in this reasonably-powered study (power ~50%) is consistent with high dose-rate predictions. Substantial bias is unlikely, and we cannot identify mechanisms by which confounding might plausibly account for the magnitude and specificity of the results. The association is therefore likely to be causal.*
> *Our results suggest that risks of childhood leukaemia apply at natural background levels of exposure at about the level extrapolated from high dose-rate data.*

Australia's track record

The 2006 Switkowski Review stated:
"There is every reason to be confident that Australia's health and safety systems will continue to provide a sound framework for the management of the uranium mining industry and would enable any other

parts of the nuclear fuel cycle envisaged for Australia to be equally well regulated, ensuring the highest levels of health and safety."[612]

However there is a wealth of contrary evidence concerning the record of organisations, corporations and agencies involved in the nuclear sector in Australia.

In the late 1990s, the federal government undermined the independence of the newly-created regulatory agency, the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), by allowing the chief executive of the Australian Nuclear Science and Technology Organisation (ASNTO) to sit on the panel which interviewed applicants for the position of CEO of ARPANSA.

The Australian National Audit Office wrote a 2005 report critical of many aspects of ARPANSA's operations.[613] The Audit Office report stated that "deficiencies in planning, risk management and performance management limit ARPANSA's ability to align its regulatory operations with risks, and to assess its regulatory effectiveness." It further stated that "procedures for licensing and monitoring of compliance have not been sufficient" and that arrangements "do not adequately support ... ARPANSA's responsibilities for transparently managing the potential for conflict of interest."

The Australian Nuclear Science and Technology Organisation (ANSTO) also has a poor track record. Tony Wood, former head of the Divisions of Reactors and Engineering at ANSTO's reactor plant in Sydney, has criticised ANSTO for its "misleading public statements" and for "sugar-coating" its information. Mr. Wood said:
"I believe that it is very important that the public be told the truth even if the truth is unpalatable. I have cringed at some of ANSTO's public statements. Surely there is someone at ANSTO with a practical reactor background and the courage to flag when ANSTO is yet again, about to mislead the public."[614]

Mr. Wood also said:
"Another document called the Sutherland Shire Local Disaster Plan is needed to cater for the public. This plan is a most remarkable document. In this case the vulnerable community represents the people in the Sutherland Shire who would be exposed in the event of a reactor accident and it lists a number of hazards to which they might be exposed, such as bushfires, earthquakes, oil spills and aircraft crashes, but there is no mention of radioactivity, among the hazards. In the whole document there is no mention of the words "iodine" or "nuclear" or " reactor" and only one mention of "ANSTO". No one would guess from reading this plan that there was a nuclear reactor in the area."[615]

A culture of secrecy undermines community confidence in ANSTO and has been the subject of frequent criticism. For example a Senate Select Committee noted in 2001:
"The Committee is highly critical of ANSTO's approach to providing documents. Its attitude seems to stem from a culture of secrecy so embedded that it has lost sight of its responsibility to be accountable to the Parliament."[616]

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[612] Switkowski Review, 2006, 'Uranium Mining, Processing and Nuclear Energy Review', http://pandora.nla.gov.au/tep/66043
[613] Australian National Audit Office, 2 March 2005, 'Regulation of Commonwealth Radiation and Nuclear Activities: Australian Radiation Protection and Nuclear Safety Agency', Audit Report No.30 2004–05, www.anao.gov.au/uploads/documents/2004-05_Audit_Report_30.pdf
[614] Tony Wood, 17 Dec 2001, presentation to ARPANSA Public Forum on Replacement Research Reactor Project, www.arpansa.gov.au/pubs/regulatory/opal/forum2.pdf
[615] Tony Wood, 17 Dec 2001, presentation to ARPANSA Public Forum on Replacement Research Reactor Project, www.arpansa.gov.au/pubs/regulatory/opal/forum2.pdf
[616] Senate Select Committee Inquiry into the Contract for a New Reactor at Lucas Heights, Final Report, May 2001, www.aph.gov.au/Parliamentary_Business/Committees/Senate/Former_Committees/lucasheights/index

Counterfeit, fraudulent and suspect items

The IAEA noted in a recent report that counterfeit, fraudulent and suspect items are a growing concern for nuclear operators:[617]

Counterfeit, fraudulent and suspect items (CFSIs) are becoming an increasing concern for operating organizations and regulators and instances of CFSIs and related quality documentation are being detected. In some cases, NPPs that are operating or that are under construction have experienced significant economic impacts, including temporary plant shutdowns, as consequences of using CFSIs. Operating organizations are taking a growing number of preventive measures, including increased awareness and training, better procurement specifications and inspections as well as a reduced use of brokers. Reporting on CFSIs, including those detected prior to plant installation, is increasingly required by regulators.

3.14 What safeguards issues are created by the establishment of a facility for the generation of electricity from nuclear fuels? Can those implications be addressed adequately? If so, by what means?

Section 2.12 addresses safeguards issues in detail.

Section 2.12 also refutes claims that Generation IV reactors would be proliferation-proof or proliferation-resistant. As the UK Royal Society notes: "There is no proliferation proof nuclear fuel cycle. The dual use risk of nuclear materials and technology and in civil and military applications cannot be eliminated."[618]

3.15 What impact might the establishment of a facility to generate electricity from nuclear fuels have on the electricity market and existing generation sources? What is the evidence from other existing markets internationally in which nuclear energy is generated? Would it complement other sources and in what circumstances? What sources might it be a substitute for, and in what circumstances?

These issues are addressed in some detail, with emphasis on the situation in South Australia, in the submission by University of NSW academic Dr Mark Diesendorf. Clearly this issue is of great importance in the South Australian context as the opportunity cost of any future nuclear development could adversely impact SA's leading renewable energy sector.

3.16 How might a comparison of the unit costs in generating electricity in South Australia from nuclear fuels as opposed to other sources be quantified, assessed or modelled? What information, including that drawn from relevant operational experience, should be used in that comparative assessment? What general considerations should be borne in mind in conducting those assessments or models?

Comparison of unit costs

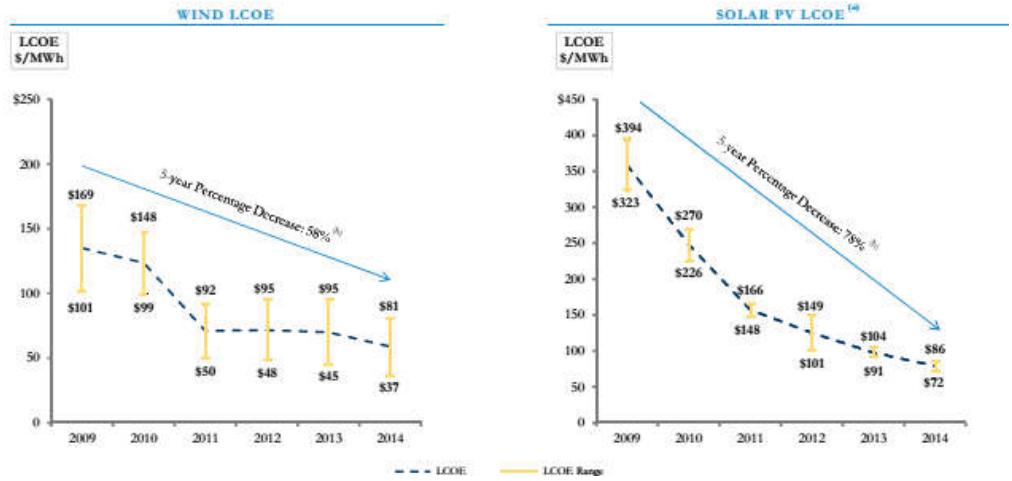
Calculations on the 'levelised cost of energy' (LCOE) factor in capital costs, fuel costs, operations and maintenance costs, financing costs, utilisation rates for different energy sources, etc. Of course, the costs vary from region to region depending on a range of factors. Moreover, costs change over time, and there

[617] IAEA, July 2015, Nuclear Technology Review 2015, www.iaea.org/About/Policy/GC/GC59/GC59InfDocuments/English/gc59inf-2_en.pdf
[618] UK Royal Society, 13 Oct 2011, 'Fuel cycle stewardship in a nuclear renaissance', http://royalsociety.org/policy/projects/nuclear-non-proliferation/report

have been striking trends over the past decade: sharply increased costs for nuclear power and sharp decreases in the costs of a number of renewable energy sources.

Multinational financial analyst Lazard estimates the unsubsidised LCOE of new nuclear power in the US to be 9.2–13.2 US cents per kilowatt hour (kWh), compared to 6.0 to 8.6 US cents per kWh for utility scale solar, and 11.8−13.0 for solar thermal with storage.[619] As Diesendorf notes[620], Lazard's 'maximum' estimate of nuclear LCOE is lower than the guaranteed price of the proposed new Hinkley C reactors in the UK (9.25 p/kWh, US 14.5 c/kWh, A 19.8 c/kWh).

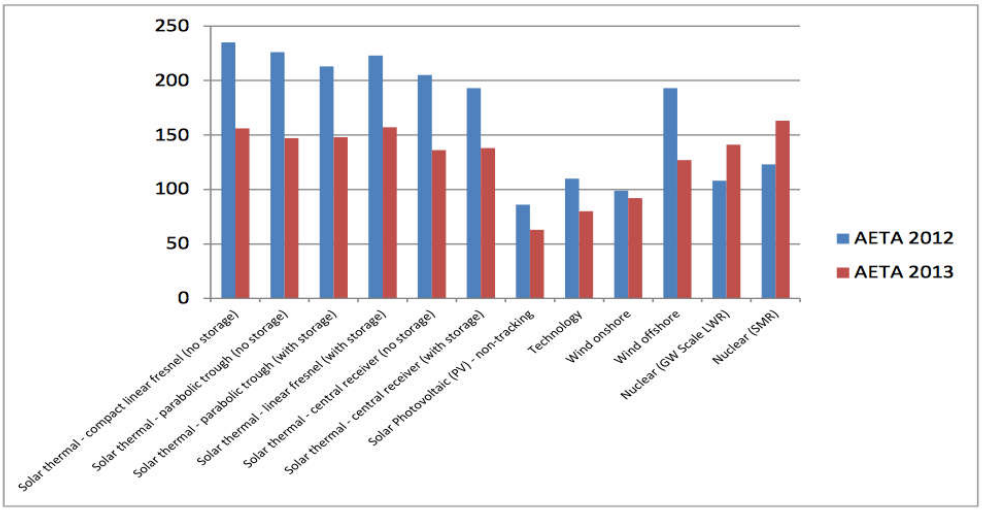
The September 2014 Lazard report also demonstrates the sharp decline in costs for solar PV and wind. The cost decline is ascribed to declines in the pricing of system components (e.g., panels, inverters, racking, turbines, etc.), and dramatic improvements in efficiency, among other factors:



Reports from the Australian government's Bureau of Resource and Energy Economics (BREE) continue to downwardly revise cost estimates for renewables.[621] Between the July 2012 and December 2013 versions of BREE's 'Australian Energy Technology Assessment', BREE's estimates of solar costs were revised downwards (in some cases by up to 30%), while estimates of nuclear costs were revised upwards. Median LCOE estimates from the July 2012 and December 2013 reports are shown in the following graph:

[619] Lazard, 2014, Levelized Cost of Energy Analysis – Version 8.0 (September), www.lazard.com/media/1777/levelized_cost_of_energy_-_version_80.pdf [Accessed 31 July 2015]
[620] Mark Diesendorf, June 2015, '100% Renewable Electricity for South Australia', www.conservationsa.org.au/images/100_Renewables_for_SA_Report_-_Dr_Mark_Diesendorf_-_web_version.pdf
[621] Giles Parkinson, 9 Jan 2014, 'A dose of reality for Australian energy cost estimates', http://reneweconomy.com.au/2014/a-dose-of-reality-for-australian-energy-cost-estimates-94767

Figure 14: Comparison of AETA 2013 Model and AETA 2012 Model LCOE estimates, selected technologies



Giles Parkinson provides the following commentary on the BREE reports:[622]

> *The revised [December 2013 BREE] report also flags that the best solar thermal with storage will be below $100/MWh. This is significant – it is way cheaper than other "dispatchable" sources such as peaking gas generation. And cleaner too.*
> *The new solar power towers with storage that are about to be commissioned in the US, and are being considered in Australia, could redefine the energy debate in those countries with the appropriate solar resource – and answer the question about dispatchability and storage.*
> *AETA's original estimates on the cost of nuclear were laughable, given real world experiences international. We said so at the time and this was confirmed by the recent deal struck by the UK government for its first nuclear plant in more than two decades. (That price was £92.50/MWh, or $A170/MWh at current exchange rates. AETA originally suggested the cost of nuclear would be below $100/MWh).*
> *Getting the LCOE right – or at least improving on the previous effort – is critical because the energy debate is high-jacked in this country by those who either don't or should know better, and will be critical as the country makes important decisions for the future in its review of the renewable energy target and the preparation of a new energy white paper.*
> *The conservative state and federal governments consistently brand renewables as expensive, when clearly they are not (although some state-based support schemes were way costlier than they needed to be because of mismanagement).*
> *Nuclear boosters – who have some sympathy within the current government – have also taken the opportunity to assert that "nuclear is cheap" – a slogan the AETA accepted in its first report with little critical analysis. Some of its most prominent hoorayers have used the CSIRO e-future modeling – which featured the absurdly low nuclear estimates – to boost their case.*
> *AETA has at least partially rectified its errors by lifting its estimates of the capital costs of nuclear by around 50 per cent – it will be interesting to see how quickly CSIRO amends its own modeling.*
> *However, the nuclear picture is still not complete because AETA has refused to include the insurance and decommissioning costs of nuclear on the basis that it does not do so for the 40 other technologies. Well, that's because other technologies do not have the same issues on either front.*
> *The cost estimates for carbon capture and storage were also significantly increased after AETA admitted it had "overlooked" the well-accepted fact that adding CCS greatly reduces the thermal*

[622] Giles Parkinson, 9 Jan 2014, 'A dose of reality for Australian energy cost estimates', http://reneweconomy.com.au/2014/a-dose-of-reality-for-australian-energy-cost-estimates-94767

efficiency of the coal-fired generators. i.e. it needs to burn more coal to produce the same amount of electricity. All this does is confirm that fossil fuels with CCS are simply not in the money.
But the AETA assessment stills fall short on many fronts because the LCOE calculations do not include interest costs – which in the case of nuclear are significant because of the sheer scale of the capital investment, and the time it takes to construct them. (It's a bit like buying a house and not worrying about the mortgage).
It also does not include variations for fuel costs (such as what happens when gas prices soar, as they are already starting to do in Queensland).
Part of the reason for the reduced cost of solar PV and solar thermal was a more informed appraisal of the operations and maintenance costs (they were reduced up to 27 per cent in the former and up to 30 per cent in the latter), and the recognition that solar has a much faster capital learning rate.
Still, there is also a suspicion that BREE has a level of bias against renewable technologies in favour of the traditional baseload installations.
For instance, it notes: "To cater for sudden, unpredictable, changes in the output of variable power plants, it is necessary to operate responsive, dispatchable power plants (e.g. hydro, open-cycle gas turbines) in a back-up role to maintain the overall reliability of the electricity system. As a result, LCOE by technology is not the only factor considered when deciding what type of electricity generation plant to construct."
There is no mention of the fact that most of these dispatchable power plants already exist because they are needed to back-up "baseload" generation, to cater for sudden changes in demand and to support unexpected outages. The fact that South Australia now has more than 31 per cent "variable generation" from wind and solar without the need for any new "back-up", should put those comments into context.

US energy analyst and consultant Chris Nelder discusses some of the nuclear-friendly distortions in cost estimates from the US government's Energy Information Administration (EIA):[623]

In the EIA's analysis, which leaves out all incentives, the average cost of "advanced nuclear" or "next-generation nuclear" plants entering service in 2018—long lead times associated with these technologies will make it difficult to open any early—would be $108.40 per megawatt-hour (MWh), equivalent to $0.1084 per kilowatt-hour (kWh), in 2011 dollars. This seems in the right ballpark, as the estimated cost of power from the new nuclear plant under construction in the Kaliningrad region of Russia is around $0.10/kWh, a German lawmaker said in April.
For reference, the 2012 average retail price of electricity in the US was $0.1153/kWh. So the cost of new advanced nuclear power would be just barely below the retail price of electricity—power sold to you and me at home. (Commercial, industrial, and transportation customers all buy power for less than the LCOE cost for advanced nuclear power.)
In other words, it would be very difficult for a utility to make money selling power generated by advanced nuclear plants, if they had to shoulder the entire cost themselves. But they don't.
Not included in the LCOE analysis is the cost of decommissioning nuclear plants, which is often externalized and pushed onto ratepayers through surcharges on their utility bills, or the cost of managing nuclear waste for decades, which is generally pushed onto taxpayers through the Department of Energy budget. And these are not trivial costs: Edison International estimates that decommissioning its San Onofre Nuclear Generating Station near San Diego, which it permanently retired last week, will cost around $3 billion. So the LCOE analysis actually understates the true, all-in cost of nuclear power.

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[623] Chris Nelder, 17 June 2013, 'The real reason to fight nuclear power has nothing to do with health risks', http://qz.com/94817/the-real-reason-to-fight-nuclear-power-has-nothing-to-do-with-health-risks

Nelder's comments on the distortions of some nuclear lobbyists (in this case the Breakthrough Institute − BTI) are worth noting:[624]

> *In its most recent analysis, "Cost of German Solar Is Four Times Finnish Nuclear", BTI compares the retail cost of German solar, which includes significant feed-in tariff incentives, to the capital cost of building a new nuclear plant in Finland, as estimated by its developer, plus the EIA's estimate for the fixed and variable costs of nuclear power. There are numerous glaring problems with this approach, but I'll name just the obvious ones.*
>
> - *It adds up the cost of all installed German solar PV from 2000-2011, a period in which the price of solar fell dramatically, and a fact that Shellenberger and Nordhaus even recognized. Thus it is weighted to the much higher costs of the past decade, rather than current costs, let alone the cost of PV in 2016 when the Finnish nuclear plant is expected to enter service. An analysis based on the actual, unsubsidized cost of German solar PV in 2016 would find that it is below the cost of new nuclear power, not four times as expensive. Even the subsidized cost would be lower. As Craig Morris pointed out last week in Renewables International, the lowest solar PV feed-in tariff ($0.13/kWh) on Germany's sliding scale is already below the cost of EDF's proposed new nuclear plant in the UK ($0.15/kWh), and one year from now, Germany's highest solar feed-in tariff will be too, at $0.13/kWh.*
> - *It's based on the post-incentive cost of German solar, not the cost of the technology. At $0.1125/kWh in the EIA's LCOE analysis, the minimum cost of solar (which is well above recent US solar PPA contracts), without incentives, is below the anticipated cost of EDF's nuclear plant in the UK.*
> - *It uses the developer's latest cost estimate for Finland's Olkiluoto 3 reactor, which Shellenberger and Nordhaus note is seven years behind schedule and nearly three times over its initial budget. Developer cost estimates should always be viewed with skepticism; an analysis by the Congressional Budget Office, cited in a 2009 analysis by the Union of Concerned Scientists, found that utility estimates for nuclear plant costs are usually around one-half the estimates of independent analysts and Wall Street. In my experience, the estimates of the latter group are usually close to the mark. Until the final costs are known, the estimates BTI cites for nuclear plants under construction in France and China are no more credible.*
> - *The PPA costs cited above for current PV installations in Germany and the US are rock-solid, contractually guaranteed prices, with no externalities. BTI is citing squishy estimates for the "overnight capital cost" (without factoring in interest rates) for a nuclear plant that won't even be completed until 2016. Which set of estimates would you consider more credible?*
>
> *Over the years I have spent many, many hours reviewing the cost estimates for new nuclear plants. Every time I've gone down that rabbit hole I have reached a point where I threw up my hands and quit because the data quality is so poor. Since no nuclear plants have been built on schedule in recent years, there are no reliable real-world cost data to establish a baseline. When you explore the various components of an estimate, you quickly find yourself in a regression of footnotes to previous papers which lead you back to estimates made a decade or more ago, before the cost of all commodities exploded in the second half of the 2000s.*
>
> *In short: Cost estimates for new nuclear plants are not credible. I have yet to find a single one that stood up to close scrutiny. And as far as I am aware, no nuclear plant has ever been built for close to its original cost estimate.*
>
> *With numerous, highly transparent LCOE analyses available from EIA, NREL, and other agencies, why does the BTI ignore them in favor of their own, partial analysis, based on a developer's cost estimate?*

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[624] Chris Nelder, 17 June 2013, 'The real reason to fight nuclear power has nothing to do with health risks', http://qz.com/94817/the-real-reason-to-fight-nuclear-power-has-nothing-to-do-with-health-risks

They appear to have begun with the predetermination that nuclear power is the only solution to everything, and then rounded up a highly selective, distorted, and outright wrong pile of evidence to make their case.
The simple fact is that, at least in the US, the nuclear industry is dying a slow death. The announced closure of four major facilities in 2013 alone amount to 4,246 megawatts of nuclear capacity—enough to power 2.7 million homes for a year—that are being retired.
Even while the nuclear industry is able to externalize its costs for insurance (which are federally limited), loan guarantees (which are federally backstopped), decommissioning (which is pushed onto ratepayers) and waste handling (which is pushed onto taxpayers), it still lost. If it had to stand on its own and pay its full insurance costs like every other energy source, we could never build another nuclear plant in America, because no private investors would be willing to take that kind of risk. It's hard to imagine how the economics could be more tilted in nuclear's favor (although I'm sure its proponents have ideas on that). ...
These are the facts: Renewables have taken the lead in new power generation in America, comprising nearly half of all new generating capacity installed in the United States in 2012. In the first quarter of this year, nearly half the new capacity installed was solar. With its poor economics, enormous complexity, overly-large capital requirements, too-long lead times, and overall risk, US nuclear power is headed for contraction, not resurgence. Ultimately, I think the same will be true globally.

Nuclear cost escalations and nuclear's negative learning curve

It is a standard characteristic of technological development that unit costs decrease over time, as the industry gains experience. Yet nuclear power is subject to a 'negative learning curve' − it has become increasingly expensive over time.[625] Citigroup states:
"The capital cost of nuclear build has actually risen in recent decades in some developed markets, partly due to increased safety expenditure, and due to smaller construction programmes (i.e. lower economies of scale). Moreover the 'fixed cost' nature of nuclear generation in combination with its relatively high price (when back end liabilities are taken into account) also places the technology at a significant disadvantage; utilities are reluctant to enter into a very long term (20+ years of operation, and decades of aftercare provisioning) investment with almost no control over costs post commissioning, with the uncertainty and rates of change currently occurring in the energy mix."[626]

Even the large-scale, standardised French nuclear power program has been subject to a negative learning curve[627]. The problem of escalating costs is worsening with the massive cost blowouts associated with the EPR projects in France and Finland. And in the UK, the estimated construction cost for an EPR in the mid- to late-2000s was £2 billion[628]; current estimates are 4-6 times higher.

In 2009, an updated version of a 2003 MIT Interdisciplinary Study on the Future of Nuclear Power was published, stating:
"The estimated cost of constructing a nuclear power plant has increased at a rate of 15% per year heading into the current economic downturn. This is based both on the cost of actual builds in Japan and Korea and on the projected cost of new plants planned for in the United States."[629]

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[625] Joe Romm, 6 April 2011, 'Does nuclear power have a negative learning curve?', http://thinkprogress.org/romm/2011/04/06/207833/does-nuclear-power-have-a-negative-learning-curve/
[626] www.businessinsider.com.au/5-charts-that-show-nuclear-is-declining-2013-10
[627] Arnulf Grubler, September 2010, 'The costs of the French nuclear scale-up: A case of negative learning by doing', *Energy Policy*, Vol.38, Issue 9, pp.5174–5188, www.sciencedirect.com/science/article/pii/S0301421510003526
[628] www.energypost.eu/saga-hinkley-point-c-europes-key-nuclear-decision/
[629] http://web.mit.edu/nuclearpower/

The high capital costs of nuclear power make it vulnerable to interest rate rises, credit squeezes and construction delays. As the World Nuclear Association notes, "long construction periods will push up financing costs, and in the past they have done so spectacularly."[630]

High capital costs make it difficult or impossible for all but the wealthiest countries and the wealthiest corporations to pursue nuclear power. Countries with annual GDP of less than US$50 billion, and electricity grid capacity of 5 GW or less, are poorly placed to be introducing nuclear power − and most countries that have expressed recent interest in introducing nuclear power do not meet both criteria.[631]

Citigroup commented on three 'Corporate Killers' in a 2009 report:
"Three of the risks faced by developers − Construction, Power Price, and Operational − are so large and variable that individually they could each bring even the largest utility company to its knees financially. This makes new nuclear a unique investment proposition for utility companies."[632]

In September 2011, German industrial conglomerate Siemens announced its intention to withdraw entirely from the nuclear industry.[633] A more recent example is the French state-owned giant Areva, which has posted losses in each of the past four years including a €4.83 billion (A$6.67b) loss in 2014. Areva chairman Philippe Varin said: "Areva's paradox is that it is a world leader in its sector and a company in crisis." Varin said the crisis was due to deficient management of big reactor projects and Areva's failure to adapt to a weaker global market following the 2011 Fukushima accident.[634]

The International Energy Agency's *World Economic Outlook 2014* report noted that nuclear growth will be "concentrated in markets where electricity is supplied at regulated prices, utilities have state backing or governments act to facilitate private investment." Conversely, "nuclear power faces major challenges in competitive markets where there are significant market and regulatory risks, and public acceptance remains a critical issue worldwide."[635]

Edward Kee from the Nuclear Economics Consulting Group noted in a February 2015 article in *World Nuclear News* that of the 69 reactors under construction around the world, only one is in a liberalised electricity market.[636]

Nuclear power is heavily subsidised.[637] Earlier promises not to subsidise new reactors in the UK have been abandoned. Construction cost estimates for two planned large EPR reactors (totalling 3.2 GW) at Hinkley Point in Somerset range from £16 billion (A$30.6b) to the European Commission's estimate (which includes financing costs) of £24.5 billion (A$46.8b), or A$9.6−14.6 billion / GW.[638] EU Competition Commissioner Joaquin Almunia said the total cost could be as high as £34 billion (A$65.9b, A$20.6/GW), a figure that EDF Energy chief executive Vincent de Rivaz said included the

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[630] World Nuclear Association, 16 February 2015, 'The Economics of Nuclear Power', www.world-nuclear.org/info/Economic-Aspects/Economics-of-Nuclear-Power/
[631] Frank von Hippel et al., 2012, 'Nuclear Energy', www.iiasa.ac.at/web/home/research/researchPrograms/Energy/GEA_Chapter14_nuclear_hires.pdf
[632] www.citigroupgeo.com/pdf/SEU27102.pdf
[633] 'Siemens to quit nuclear industry', 18 Sept 2011, www.bbc.co.uk/news/business-14963575
[634] Geert De Clercq, 4 March 2015, 'Loss-making Areva bets on cost cuts, EDF cooperation, China', www.reuters.com/article/2015/03/04/areva-results-idUSL5N0W60I420150304
[635] International Energy Agency, 2014, 'World Economic Outlook 2014', www.worldenergyoutlook.org
[636] World Nuclear News, 4 Feb 2015, 'Can nuclear succeed in liberalized power markets?', www.world-nuclear-news.org/V-Can-nuclear-succeed-in-liberalized-power-markets-0420152.html
[637] World Information Service on Energy, 24 June 2005, 'UNFAIR AID: The subsidies keeping nuclear energy afloat', www.wiseinternational.org/node/3163
[638] European Commission, 8 Oct 2014, http://europa.eu/rapid/press-release_IP-14-1093_en.htm

maximum EDF could have to put into the project in a worst-case scenario if there were "huge problems".[639]

The UK government is offering loan guarantees of £10 billion (A$19.3b) for the Hinkley Point project. The UK government is also guaranteeing French utility EDF £89.50 (A$173.30) for every megawatt-hour generated by the Hinkley Point reactors, fully indexed for inflation, for 35 years. For comparison, the guaranteed payment of A$173.30/MWh is 2.7 times greater than typical wholesale electricity purchase costs in Australia of around A$65/MWh.[640] The legality of the subsidies is likely to be challenged by Austria (and others) under EU regulations.

Other costs are also spiralling in the UK. The UK National Audit Office estimates the total future costs for decommissioning the (dual civil-military) Sellafield nuclear site in Cumbria will be £67 billion (A$130b) − well up from the 2009 estimate of £47 billion (A$91b).[641] Estimates of the clean-up costs for a range of (civil and military) UK nuclear sites including Sellafield have jumped from a 2005 estimate of £56 billion (A$108b) to over £100 billion (A$193b).[642]

The estimated cost of the Flamanville EPR in France has increased from €3.3 billion (A$4.7b) to at least €9 billion (A$12.8b).[643] The first concrete was poured at Flamanville in 2007 and commercial operation was expected in 2012. That timeframe has been pushed back five years to 2017 with further delays likely.[644] The British *Daily Mail* characterised the Flamanville EPR project as one "beset by financial mismanagement with rocketing costs, the deaths of workers, an appalling inability to meet construction deadlines, industrial chaos, and huge environmental concerns", and notes that "it continues to be plagued by delays, soaring costs, and litigation in both the criminal and civil courts."[645]

Since the contract was signed in 2003 for a new EPR in Finland, the estimated cost has risen from €3.2 billion (A$4.6b) to €8.5 billion (A$12.1b). Areva has already made provision for a €2.7 billion (A$3.8b) write-down on the project, with further losses expected.[646] French and Finnish utilities have been locked

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[639] Emily Gosden, 8 Oct 2014, 'Hinkley Point nuclear plant to cost £24.5bn', www.telegraph.co.uk/finance/newsbysector/energy/11148193/Hinkley-Point-nuclear-plant-to-cost-34bn-EU-says.html

[640] NERA Economic Consulting, 19 Aug 2013, 'Wholesale Electricity Costs in the NEM', p.15, www.aemc.gov.au/getattachment/83698230-ac57-43b2-a8e0-e4bae4acce3f/NERA-Wholesale-Electricity-Costs-in-the-NEM.aspx

[641] Emily Gosden, 20 June 2013, 'Sellafield clean-up could be taken into state hands as £22bn contract up for review', *The Telegraph*, www.telegraph.co.uk/finance/newsbysector/energy/10133528/Sellafield-clean-up-could-be-taken-into-state-hands-as-22bn-contract-up-for-review.html

[642] Jonathan Leake, 9 Dec 2012, 'Nuclear cleanup to take 120 years and cost £100bn', www.thesundaytimes.co.uk/sto/news/uk_news/National/article1173042.ece

[643] 21 Apr 2015, France's nuclear calamity has UK worried, www.thelocal.fr/20150421/flamanville-frances-own-nuclear-nightmare

Carol Matlack, 16 April 2015, 'Areva Is Costing France Plenty', www.bloomberg.com/news/articles/2015-04-16/france-s-areva-falters-in-reactor-business-leaks-cash

[644] World Nuclear Association, March 2015, 'Nuclear Power in France', www.world-nuclear.org/info/Country-Profiles/Countries-A-F/France/

[645] Steve Bird, 26 Oct 2013, 'Deaths, chilling safety lapses, lawsuits, huge cost over-runs and delays: Why we can't trust the French with Britain's nuclear future', www.dailymail.co.uk/news/article-2477202/Deaths-chilling-safety-lapses-lawsuits-huge-cost-runs-delays-Why-trust-French-Britains-nuclear-future.html

[646] World Nuclear Association, April 2015, 'Nuclear Power in Finland', www.world-nuclear.org/info/Country-Profiles/Countries-A-F/Finland/

in legal battles for several years over the cost overruns.[647] The project is nine years behind schedule − the start-up date has been pushed back from 2009 to 2018.[648]

A similar pattern is evident with new reactor projects in the US: lengthy delays and large cost escalations. Mark Cooper, senior fellow for economic analysis at Vermont Law School's Institute for Energy and the Environment, states:
"In contrast to the success of the alternatives, the projected cost of nuclear power has increased five-fold since technology vendors and academic boosters declared the "Nuclear Renaissance" in the mid-2000s. If the industry had been able to deliver on the hype of a decade ago, it would not be in such dire straits. Having failed miserably a second time, the industry is demanding another round of massive subsidies, relaxed oversight, and pampered treatment for a third bite at the apple."[649]

Generation IV reactors

Claims that 'Generation IV' reactors will produce cheap electricity are baseless. Fast neutron reactors are neither new nor cheap. For example, the French Superphenix fast neutron reactor was promoted as the first commercial-scale fast breeder reactor in the world but the electricity it produced is estimated to have cost US$1.33 per kilowatt-hour.[650] That is over 20 times greater than typical wholesale electricity purchase costs in Australia of around A$65/MWh.[651]

Some are promoting 'small modular reactors' with baseless claims that they will provide cheap power. If small modular reactors ever provide affordable power, it will result from large production chains producing large numbers of identical units − but no company (or government) is even considering investing the required billions in such a construction chain. Argentina is constructing a 27 MWe reactor − but the estimated cost of ARS3.5 billion[652] (A$521 million) equates to A$19.3 billion per 1000 MWe.

Nuclear newcomers

The introduction of nuclear power in Australia − or any other countries building nuclear power plants for the first time − would incur additional, very large start-up costs such as those associated with the acquisition of greenfield sites and the recruitment and training of a large workforce.

Costing accidents

In 2012, the American Society of Mechanical Engineers (AMSE) provided a "rough estimate" of US$500 billion total costs from the Fukushima accident, covering on-site clean-up and decommissioning

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[647] World Nuclear News, 6 July 2012, 'Partial ruling on Olkiluoto 3', www.world-nuclear-news.org/-Arbitration_court_rules_on_Olkiluoto_3-0607124.html
World Nuclear Association, April 2015, 'Nuclear Power in Finland', www.world-nuclear.org/info/Country-Profiles/Countries-A-F/Finland/
[648] Reuters, 1 Sept 2014, 'Finland's nuclear plant start delayed again; Areva, TVO trade blame', www.reuters.com/article/2014/09/01/finland-nuclear-olkiluoto-idUSL5N0R20CV20140901
[649] Mark Cooper, 20 Feb 2014, 'Why The Economics Don't Favor Nuclear Power In America', www.forbes.com/sites/energysource/2014/02/20/why-the-economics-dont-favor-nuclear-power-in-america/
[650] Salahodeen Abdul-Kafi, 30 March 2011, 'The Superphénix Fast-Breeder Reactor', http://large.stanford.edu/courses/2011/ph241/abdul-kafi1/
[651] NERA Economic Consulting, 19 Aug 2013, 'Wholesale Electricity Costs in the NEM', p.15, www.aemc.gov.au/getattachment/83698230-ac57-43b2-a8e0-e4bae4acce3f/NERA-Wholesale-Electricity-Costs-in-the-NEM.aspx
[652] www.world-nuclear-news.org/NN-Construction-of-CAREM-underway-1002144.html

costs, clean-up of contaminated lands outside the Fukushima plant boundary, replacement power costs due to shutdown of all of Japan's reactors, and compensation for citizens evacuated from their homes.[653]

AMSE noted that the figure would "substantially increase if nuclear electricity generation continues to be replaced for a long time by other means" − as it has.

A cost of US$500 billion (A$685 billion) equates to over A$400,000 for every man, woman and child in South Australia. A Fukushima-scale accident would economically cripple the state.

Nuclear liability

Inadequate liability arrangements amount to a large subsidy for nuclear power, and they are also problematic in many other respects. The problems have been abundantly clear in the aftermath of the Fukushima disaster − utility TEPCO has no hope of meeting costs arising from the disaster so additional costs are met by taxpayers; and, among other problems, suppliers cannot be held accountable for their failings.

A 2013 paper commissioned by Greenpeace contrasts the current reality with liability arrangements with a hypothetical and more robust system:[654]

> *The core problems of nuclear liability are:*
> - *The objectives of international liability conventions are competing, if not mutually exclusive. First, they limit the extent of possible compensation claims, creating an economic environment that allowed the nascent nuclear industry to flourish. Secondly, they are supposed to grant victims access to full and timely compensation in the event of an accident.*
> - *Only the operator of a nuclear power plant can be held responsible for paying for damages. Nuclear suppliers, who build and service plants, do not have to pay anything.*
> - *The total amount of compensation available is limited, but these limits are well below the true cost of a nuclear accident.*
> - *Definitions of nuclear damage do not cover all damages caused by a nuclear disaster.*
> - *Potential victims in other countries can only sue for compensation in the country where the nuclear accident happened, not in their own courts.*
>
> *To create a system that is fairer and puts people ahead of business, the following must happen:*
> - *No limits to the total amount of compensation.*
> - *Hold the whole nuclear industry, including suppliers, accountable.*
> - *Ensure adequate financial coverage by companies. A major nuclear accident would almost certainly bankrupt any private utility.*
> - *Allow people to recover all damages caused by a nuclear disaster.*
> - *Increase transparency into costs and liability insurances.*

Recommendation 44: The Royal Commission should recommend that, if plans for nuclear power or nuclear fuel cycle facilities (including waste stores or repositories) are advanced, that a world's best

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[653] American Society of Mechanical Engineers, June 2012, 'Forging a New Nuclear Safety Construct: The ASME Presidential Task Force on Response to Japan Nuclear Power Plant Events', www.asme.org/getmedia/73081de8-e963-4557-9498-f856b56dabd1/Forging_a_new_nuclear_safety_construct.aspx

[654] Antony Froggatt, Dr David McNeill, Prof Stephen Thomas and Dr Rianne Teule, Feb 2013, 'Fukushima Fallout: Nuclear business makes people pay and suffer', www.greenpeace.org/international/Global/international/publications/nuclear/2013/FukushimaFallout.pdf, pp7-8

practice liability regime should be put in place, with no limits on the amount of compensation payable, and suppliers as well as operators held accountable.

Finance

Former World Nuclear Association executive Steve Kidd wrote in a June 2015 article:[655]

> *The argument that a shortage of finance, or the cost of it, are significant barriers to new nuclear projects is frequently heard and, indeed, industry conferences have been organised largely around this theme. The truth, however, is rather different: finance is not so much an input into a nuclear project as an output.*
> *While everyone recognises that nuclear projects are extremely capital intensive, requiring lots of finance in the early stages that can only be paid back over a long period of operations, there is no unique financing mechanism that the relevant institutions can come up with to rescue a nuclear project that has questionable returns or too high a degree of risk for investors. This is the real problem: nuclear projects have largely become too expensive and risky to offer lenders the degree of assurance they require. Although there have been blanket bans on investing in nuclear within some of the development banks, this cannot all be politically inspired. Even with government incentives such as loan guarantees, fixed electricity prices and certain power offtake, nuclear projects today struggle to make economic sense, at least in the developed world. There are lots of different ways of generating electricity and the cost and schedule overruns at the latest projects are a warning to potential investors. They cannot be expected to put in either equity or loan finance if the prospective returns are inferior to those of other projects.*
> *There is plenty of money available around the world today seeking good projects and financial markets are very creative at efficiently putting together the savers of the world and the likely borrowers. World interest rates are currently low, which removes one disadvantage of capital intensive projects. These low rates indicate that there is funding available but a possible shortage of viable projects. This dearth of opportunities clearly goes some way beyond the nuclear sector. The onus is, however, on the industry to come up with the projects that make economic sense. If costs are too high, ways have to be found to cut them. If building a reactor over six years is too risky, they have to be built in four. When a project demonstrates that it is viable, banks will be falling over themselves to provide finance. But if it doesn't, there is little they can do to help.*
> *The current fashion for vendor financing doesn't really get nuclear away from this problem, unless there is a government subsidy behind it. Even if a vendor can come up with US$20billion for a four-unit plant (as Rosatom of Russia is apparently promising for Akkuyu in Turkey), it must still be sure of getting its money back at some point. Even with guaranteed power prices, will electricity customers in another country be able and willing to pay for the next twenty years? Vendors in the private sector only have market-related finance available to them, so cannot realistically get involved in this sort of project.*

3.17 Would the establishment of such facilities give rise to impacts on other sectors of the economy? How should they be estimated and using what information? Have such impacts been demonstrated in other economies similar to Australia?

See section 1.13. Discussion on the impacts on other sectors needs to factor in the possibility of major accidents. The Fukushima disaster has destroyed the regional economy, and direct and indirect costs are

[655] Steve Kidd, 11 June 2015, 'Nuclear myths – is the industry also guilty?', www.neimagazine.com/opinion/opinionnuclear-myths-is-the-industry-also-guilty-4598343/

likely to exceed US$500 million (A$685 billion).[656] An accident of that magnitude would devastate the South Australian economy.

Issues Paper #4: Management, Storage and Disposal of Waste

4.1. Are the physical conditions in South Australia, including its geology, suitable for the establishment and operation of facilities to store or dispose of intermediate or high level waste either temporarily or permanently? What are the relevant conditions? What is the evidence that suggests those conditions are suitable or not? What requires further investigation now and in the future?

Dr Mike Sandiford from the School of Earth Sciences at University of Melbourne writes:[657]

> *Australia is relatively stable but not tectonically inert, and appears to be less stable than a number of other continental regions. Some places in Australia are surprisingly geologically active.*
>
> *We occasionally get big earthquakes in Australia (up to about magnitude 7) and the big ones have tended to occur in somewhat unexpected places like Tennant Creek. The occurrences of such earthquakes imply that we still have much to learn about our earthquake activity. From the point of view of long-term waste disposal this is very important, since prior to the 1988 (M 6.8) quake, Tennant Creek might have been viewed as one of the most appropriate parts of the continent for a storage facility.*
>
> *Australia is not the most stable of continental regions, although the levels of earthquake risk are low by global standards. To the extent that past earthquake activity provides a guide to future tectonic activity, Australia would not appear to provide the most tectonically stable environments for long-term waste facilities. However, earthquake risk is just one of the 'geologic' factors relevant to evaluating long-term integrity of waste storage facilities, and other factors such as the groundwater conditions, need to be evaluated in any comprehensive assessment of risk.*

The SA State Emergency Services states:[658]

> *Any part of Australia could experience an earthquake. There is no accepted method to predict earthquakes, however, some regions are more earthquake-prone than others. Parts of South Australia including Adelaide and the mid-north are earthquake hazard areas with a high potential for future earthquakes.*

<u>Social dimensions of risk assessment</u>

There are social as well as technical dimensions to risk assessments. For example, the 'clean up' of Maralinga was badly mishandled because the government officials had little or no project management experience and little or no understanding of the technical risks, and because the federal government wasn't prepared to spend the money to carry out the clean-up properly.[659]

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[656] American Society of Mechanical Engineers, June 2012, 'Forging a New Nuclear Safety Construct: The ASME Presidential Task Force on Response to Japan Nuclear Power Plant Events', www.asme.org/getmedia/73081de8-e963-4557-9498-f856b56dabd1/Forging_a_new_nuclear_safety_construct.aspx

[657] ABC, 'Ask an Expert', www.abc.net.au/science/expert/realexpert/nuclearpower/08.htm

[658] www.ses.sa.gov.au/site/community_safety/earthquake_information.jsp [accessed 31 July 2015]

[659] See section 1.9 of this submissions.
See also: www.foe.org.au/anti-nuclear/issues/oz/britbombs/clean-up

The scale of the incompetence associated with the Maralinga clean-up (discussed in section 1.9) warrants emphasis. Nuclear engineer Alan Parkinson has this to say about senior government officials responsible for the Maralinga 'clean up':

> "Different members of the department's team (a) did not know what is meant by alpha radiation (plutonium-239, the main contaminant at Maralinga, emits alpha radiation), (b) thought that a milliSievert (a unit of radiation dose) could be converted to a picoCurie (a unit of radioactivity) and (c) stated that soda ash (an alkaline substance) would be neutralised by the limestone (another alkaline substance) at the site. The person who made the last statement also told a Senate committee that limestone is "rich in sodium and carbonate" with no mention of calcium (limestone is calcium carbonate). One of those people told me *"When dealing with contractors, you should always seek compromises."* Further details of such ignorance are related in *Alan Parkinson, Submission to The Senate Select Committee for an Inquiry into the Contract for a New Reactor at Lucas Heights, September 2000."*

Likewise, hazards associated with the planned national waste repository in SA were increased by incompetent project management. Nuclear physicist Prof. Peter Johnston (now with ARPANSA) noted that "there were ... very large expenditures **and significant hazards** resulting from the deficient management of the project by DEST [the Department of Education, Science and Training]."[660] (emphasis added)

If lessons were learnt from the Maralinga 'clean up' − and from mismanaged (and failed) attempts to establish a national repository − there might be some cause for optimism. However there is no evidence that lessons have been learnt.

4.2 Are there nuclear or radioactive wastes produced in Australia which could be stored at a facility in South Australia? In what circumstances would the holders of those wastes seek to store or dispose of that waste at facilities in South Australia?

Australia has a stockpile of 4,000 to 5,000 cubic metres of low- and intermediate-level waste that could theoretically be stored or disposed of in South Australia. However there would be little or no gain in so doing:

- No compensation or benefits were on offer when the federal government attempted to impose a repository in SA from 1998−2004. No ongoing jobs were envisaged; not even a small on-site security workforce.
- From 2005−2014, the federal government was offering a compensation package of $12 million − a very modest sum for a facility that would pose environmental and public health hazards for several hundred years. No ongoing jobs were envisaged other than a very small on-site security workforce.

Management of Australia's waste requires broader consideration. For example ANSTO is the source of most of the waste (measured by radioactivity) and around half the waste (measured by volume) and ongoing management of waste at ANSTO is both possible and might be the best option. That issue, and others, should be addressed by a dedicated National Commission or comparable public inquiry mechanism into advancing responsible radioactive waste management in Australia.

See also: Alan Parkinson, 2015 submission to Nuclear Fuel Cycle Royal Commission, http://nuclearrc.sa.gov.au/app/uploads/2015/08/Alan-Parkinson-12-06-2015.pdf

[660] 2004, Submission to ARPANSA inquiry into proposed repository in SA, www.foe.org.au/anti-nuclear/issues/oz/britbombs/clean-up

The primary purpose of a National Commission would be to thoroughly assess all options for radioactive waste management in Australia. It would restore procedural and scientific rigour, and stakeholder and community confidence in radioactive waste management. Comparable processes overseas − such as the UK Committee on Radioactive Waste Management (CoRWM)[661], and the Blue Ribbon Commission[662] process in the United States − should be considered during the establishment of a National Commission, and by the Commission itself.

Recommendation 45: The Royal Commission should recommend the establishment of a National Commission to thoroughly evaluate all options for managing Australia's radioactive waste.

Parallel to a National Commission − or prior to a National Commission − an audit of existing waste stockpiles and storage facilities needs to be conducted. This could be led by ARPANSA in consultation with relevant state agencies with responsibility for radioactive waste. Specific issues include:

- volume/mass and radioactivity of waste at each current storage site;
- whether waste production is ongoing at each particular site and if so, whether storage capacity has been reached or is approaching and if so, whether increasing storage capacity is an option;
- nature and adequacy/inadequacy of current storage conditions;
- nature and adequacy/inadequacy of institutional control.

This audit would include developing a prioritised program to improve continuing waste storage and handling facilities, and identifying non-recurrent or legacy waste sites and exploring options to retire and de-commission these.

For detailed discussion on Australia's Australian radioactive waste management issues see the following two papers:

- Anica Niepraschk, July 2015, 'Wasting Time? International lessons for managing Australia's radioactive waste', Australian Conservation Foundation, www.acfonline.org.au/resources/wasting-time-international-lessons-managing-australias-radioactive-waste-–-discussion
- Jim Green, Natalie Wasley, Dave Sweeney, November 2014, 'Responsible Radioactive Waste Management in Australia: The Case for an Independent Commission of Inquiry', www.foe.org.au/sites/default/files/Responsible%20Radioactive%20Waste%20Management%20-%20The%20need%20for%20an%20Inquiry-Final.pdf

Waste from a nuclear power program in Australia

Former Chair of the Board of the Australian Nuclear Science and Technology Organisation, Ziggy Switkowski, has been promoting the construction of 50 nuclear power reactors in Australia.[663]

Over a 50-year lifespan, 50 (1 GW) reactors would:

- be responsible for 1.8 billion tonnes of low-level radioactive tailings waste (assuming the uranium came from Olympic Dam).
- be responsible for 430,000 tonnes of depleted uranium waste.
- produce 75,000 tonnes of high-level nuclear waste (approx. 25,000 cubic metres).
- produce 750,000 cubic metres of low-level waste and intermediate level waste.
- produce 750 tonnes of plutonium, enough for 75,000 nuclear weapons.

661 www.gov.uk/government/organisations/committee-on-radioactive-waste-management
662 http:/brc.gov
663 Ziggy Switkowski, 3 Dec 2009, 'Australia must add a dash of nuclear ambition to its energy agenda', www.smh.com.au/opinion/politics/australia-must-add-a-dash-of-nuclear-ambition-to-its-energy-agenda-20091201-k3pq.html

As the Switkowski Review noted:
"Establishing a nuclear power industry would substantially increase the volume of radioactive waste to be managed in Australia and require management of significant quantities of HLW [high level waste]."[664]

Former Liberal Party Senator Nick Minchin has commented on the difficulty of managing wastes from a nuclear power program:[665]
"My experience with dealing with just low level radioactive waste from our research reactor tells me it would be impossible to get any sort of consensus in this country around the management of the high level waste a nuclear reactor would produce."

4.3 Would the holders of nuclear or radioactive waste outside Australia seek to store or dispose of that waste in South Australia? Who holds that waste? What evidence is there that they are seeking options to store or dispose of wastes elsewhere including in locations like South Australia? If so, what kinds of waste and what volumes might be expected? What would the holders be willing to pay and under what arrangements?

The question regarding possible revenue is addressed later, in response to questions 4.4 and 4.11.

Introduction

There is a precedent to current discussions about establishing an international high-level nuclear waste repository in Australia. Pangea Resources was an international consortium that was planning such a repository in Australia.[666] Pangea set up an office in Australia in the late 1990s but gave up in 2002 in the face of overwhelming public and political opposition. The existence of Pangea Resources was a closely guarded secret until a corporate video was leaked to the media. Pangea chief Jim Voss denied meeting with federal government ministers when he had in fact met at least one minister. A Pangea spokesperson said: "We would not like to be lying ... we very much regret getting off on the wrong foot." Ironically, ARIUS, the successor to Pangea, now states: "An essential element of any approach is the open and complete flow of information."[667]

Successive federal governments have failed to find a lasting solution for the management of Australia's low- and intermediate-level waste. Yet now there are advocates for Australia managing vastly greater amounts of far more hazardous high-level nuclear waste.

Recommendation 46: The Royal Commission should recommend that any further discussion on accepting international waste should be put on hold until lasting solutions are implemented to safely manage Australia's radioactive waste.

National policies

No country has ever imported spent nuclear fuel or high-level nuclear waste as a commercial venture (other than the import of spent fuel for reprocessing). For that reason, and others, it is impossible to assess how many countries (and nuclear utilities) might be interested in sending spent fuel or high level nuclear waste to Australia for storage and/or disposal.

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[664] Switkowski Review, 2006, Uranium Mining, Processing and Nuclear Energy Review, http://pandora.nla.gov.au/tep/66043
[665] Brad Crouch, 21 May 2006, 'No nuke plant in 100 years', *The Advertiser*.
[666] www.foe.org.au/anti-nuclear/issues/oz/import-waste
[667] http://nuclearrc.sa.gov.au/app/uploads/2015/08/Arius-Association-13-07-2015.pdf

There may be countries that would be willing to send nuclear waste to Australia for storage and/or disposal but there are many reasons why countries may choose other options:

- Countries which have no spent fuel or high level waste.
- Countries (or companies/utilities) that would consider it irresponsible to entrust nuclear waste to a country that has very little or no experience or demonstrated competence − and a proven track record of incompetence, e.g. the Maralinga 'clean up'.
- Countries (or companies/utilities) that would consider it unethical to send nuclear waste to Australia given the demonstrated pattern of Aboriginal land rights and heritage protections being sacrificed in order to advance radioactive waste repository projects (e.g. the extinguishment of Native Title rights and interests to advance the planned national repository in SA; and legislation allowing the imposition of a radioactive waste repository in the NT with no Aboriginal consultation or consent).
- Countries that are pursuing spent fuel reprocessing would seem unlikely candidates (see below).
- Countries (or companies/utilities) that would consider it unethical or inappropriate to send nuclear waste to Australia given the inevitability of deep community division.
- Countries that see spent fuel as a military asset (as it contains weapons-useable plutonium).
- Countries that are advancing domestic or regional disposal plans.

Of course, a vast majority of the world's countries (~160/194) have not operated power reactors and do not have spent fuel or high level nuclear waste stockpiles. Some of these countries do however have stockpiles of long lived waste from medicine, industry or research requiring disposal.

Countries with reprocessing plants (or which send spent fuel overseas for reprocessing) are presumably not interested in sending spent fuel to Australia; though some might consider sending the high level waste stream from reprocessing to Australia. However ARIUS, the successor to Pangea, notes that "reprocessing nations are likely to take care of their own wastes".[668]

The IAEA summarises the situation with reprocessing in its 'Nuclear Technology Review 2015':[669]

"In 2014, about 10 000 t HM were discharged as spent fuel from all NPPs. The total cumulative amount of spent fuel that has been discharged globally is approximately 380 500 t HM, of which about 258 700 t HM are stored in facilities at either at-reactor or away-from-reactor sites. Less than a third of the cumulative amount of spent fuel discharged globally has already been reprocessed. In 2014, the global commercial reprocessing design capacity, spread across five countries (France, India, Japan, the Russian Federation and the United Kingdom), was about 4800 t HM per year. However, not all this capacity is operational."

Some countries are planning new or expanded reprocessing facilities, such as Russia's RT-2 reprocessing plant which is expected to be operational by 2021.[670]

BHP Billiton's submission to the Switkowski Review stated:[671]

"We strongly doubt the acceptability of any government or commercially imposed requirement to lease fuel, as distinct from acquiring uranium, to our major customers, all of whom are highly respected utilities in countries with which Australia has rigorous safeguards agreements, and who have choices

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[668] http://nuclearrc.sa.gov.au/app/uploads/2015/08/Arius-Association-13-07-2015.pdf
[669] IAEA, July 2015, Nuclear Technology Review 2015, www.iaea.org/About/Policy/GC/GC59/GC59InfDocuments/English/gc59inf-2_en.pdf
[670] IAEA, July 2015, Nuclear Technology Review 2015, www.iaea.org/About/Policy/GC/GC59/GC59InfDocuments/English/gc59inf-2_en.pdf
[671] http://web.archive.org/web/20070830182528/www.pmc.gov.au/umpner/submissions/223_sub_umpner.pdf

about where to acquire their U3O8. These utilities generally regard their spent fuel as an asset − a resource for future reprocessing to produce more fuel input."

The EU Council Directive 2011/70/Euratom legally binds EU Member States to establish and maintain a spent fuel and radioactive waste management policy, and states that Each EU Member State shall have ultimate responsibility for managing the spent fuel and radioactive waste generated in it.[672]

South Korea has been actively lobbying for some years for the relaxation of a prohibition on reprocessing and may wish to pursue that path rather than sending spent fuel to another country.

Other countries are pursuing domestic repository projects and would therefore be unlikely to want to send spent fuel or high level waste to Australia. That would apply to the countries with the most advanced repository projects − Sweden, Finland and France. It might also apply to countries such as Canada, which is progressing plans for a low- and intermediate-level waste repository near Lake Huron and is slowly progressing plans for a high level waste repository.

China has plans for reprocessing and a domestic repository. The IAEA states:
"China foresees geological disposal needs deriving from the reprocessing of 140 000 tonnes of spent fuel from a fleet of 48 reactors. Disposal is to be sited in either a crystalline or a sedimentary host formation, and construction of the first underground research facility (URF) is planned in the Beishan area. The results expected from this URF will contribute to informing future decisions on deep geological disposal implementation."

A moral responsibility?

Some argue that Australia has a moral responsibility to accept the high level nuclear waste arising from the use of Australian uranium in power reactors overseas. In fact and in practice, the responsibility for managing nuclear waste lies with the countries that make use of Australian uranium. There are no precedents for Australia or any other country being morally or legally responsible for managing wastes arising from the use of exported fuels, or from the export of any other products.

If any moral responsibility lies with Australia, that responsibility arguably rests with the uranium mining companies (which are foreign-owned or majority foreign-owned) rather than with Australian citizens or federal or state governments. Such responsibility could be framed in 'cradle-to-grave' or life-cycle stewardship arguments of corporate social responsibility.

One plausible scenario is uranium being mined on Aboriginal land regardless of Aboriginal opposition, and high level nuclear waste being dumped on Aboriginal land, again without consent. That scenario is unethical twice over.

It is also argued that Australia has a moral responsibility to accept high level nuclear waste because Australia has more suitable geology than other countries, and/or or a more stable political system. Those arguments rest on questionable assumptions. Australia is less tectonically stable than a number of other continental regions according to Dr Mike Sandiford.[673] On the basis of the flawed Maralinga clean-up, there is no reason to believe that a high level nuclear repository (or a waste-to-fuel recycling project) would be carefully and responsibly managed in Australia, or that regulation would be rigorous and independent.

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[672] IAEA, July 2015, Nuclear Technology Review 2015, www.iaea.org/About/Policy/GC/GC59/GC59InfDocuments/English/gc59inf-2_en.pdf
[673] ABC, 'Ask an Expert', www.abc.net.au/science/expert/realexpert/nuclearpower/08.htm

The Northern Territory Minerals Council has questioned whether Australia has an obligation to accept nuclear waste: [674]
"In terms of the proposition of taking back nuclear waste, that should be viewed as an economic rather than a moral decision. I do not think that it follows, as some have said, that because we produce uranium we have a moral obligation to take back spent fuel rods and the like. The vast quantity of economic benefit is derived by those producing power and selling it down the track. The percentage we derive from selling the product is minuscule. If it makes economic sense, by all means look at it on that economic and scientific basis, but I do not think there is a moral obligation to do it."

Likewise, Alan Layton from the Association of Mining and Exploration Companies said: [675]
"The only observation I would make is that there is probably an argument that there is some safety in burying the wastes close to where the product is used, rather than transporting them. I am not certain about this notion that when we sell uranium we necessarily have to take back its wastes."

4.4 What sorts of mechanisms would need to be established to fund the costs associated with the future storage or disposal of either Australian or international nuclear or radioactive wastes? Are there relevant models in operation which should be considered? What mechanisms need to be put in place to increase the likelihood that the South Australian community, and relevant parts of it, derive a benefit from that activity?
4.11 What financial or economic model or method ought be used to estimate the economic benefits from the establishment or operation of facilities for the storage or disposal of nuclear and radioactive waste? What information or data (including that drawn from actual experience in Australia or overseas) should be used in that model or method?

Possible revenue

Little can be said about possible revenue from accepting nuclear waste given that there are no precedents for a commercial venture of this nature, and no way of knowing how many countries might be interested in sending waste to Australia, how much waste would be involved, etc.

Thus the figures that have been offered (in the media and elsewhere) are arbitrary. Pangea planned to transport 75,000 tonnes of spent fuel over 40 years. Pangea-successor ARIUS states that commonly quoted potential prices for accepting spent nuclear fuel for disposal are in the order of US$1M/ton.[676] Thus the income might have been around US$1.88 billion/year. That (arbitrary) figure needs to be set against the inevitable costs, including some tens of billions for a repository.

Other figures are not only arbitrary but absurd − in particular, analyses which add up all the revenue that could be generated at each stage of a nuclear fuel leasing program without grounding that analysis in the reality that a number of relevant markets (e.g. conversion, enrichment) already have substantial excess capacity.

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[674] House of Representatives – Federal Standing Committee on Industry and Resources, Dec 2006, 'Australia's uranium: Greenhouse friendly fuel for an energy hungry world', ch.12, www.aph.gov.au/Parliamentary_Business/Committees/House_of_Representatives_Committees?url=isr/uranium/report.htm
[675] House of Representatives – Federal Standing Committee on Industry and Resources, Dec 2006, 'Australia's uranium: Greenhouse friendly fuel for an energy hungry world', transcript of hearings, 23 Sept 2005, http://parlinfo.aph.gov.au/parlInfo/download/committees/commrep/8750/toc_pdf/4256-2.pdf;fileType=application%2Fpdf#search=%22committees/commrep/8750/0000%22
[676] http://nuclearrc.sa.gov.au/app/uploads/2015/08/Arius-Association-13-07-2015.pdf

Some nuclear proponents believe that spent nuclear fuel is a "multi-trillion dollar asset"[677] − because it can be processed for reuse as reactor fuel − and they also believe that countries will pay "tens of billions of dollars"[678] to relieve themselves of this multi-trillion dollar asset. However, to the extent that countries regard spent fuel as an asset, they will:

- not be willing to send it to Australia;
- offer to sell spent fuel to Australia rather than paying Australia to take it; or
- they may pay Australia to take spent fuel but they will pay less to the extent that spent fuel is considered an asset.

Costs

It would be speculative, to put it mildly, to pursue a plan to process spent fuel for use as fuel in Integral Fast Reactors (IFRs) given that no IFRs exist. Advocates of that plan claim that waste would be recycled until only relatively short-lived waste remains. Given that IFRs do not exist, a more likely outcome is that Australia would have stockpiles of spent fuel / high level waste requiring long term management and disposal. Most likely, some of the facilities (processing facilities, reactors) would themselves be classed as long-lived intermediate-level waste after usage and would thus be destined for deep geological disposal.

Thus, claims that Australia could simply store nuclear waste without any disposal plans for long lived waste should be rejected.

Even if the IFR waste-to-fuel such a plan were to be pursued, the possibility/likelihood that Australia would still have long-lived waste requiring deep geological disposal would need to be factored into planning. It would be irresponsible to pursue a waste-to-fuel without having firm plans for a deep geological repository, funds to build such a facility, a site for the facility, and relevant licences.

Since the volume of waste would presumably be relatively large (as a commercial venture), the cost would likely be in the tens of billions of dollars. Plans for a high level waste repository in Japan may be comparable: the estimated cost is ¥3,500 billion (A$38.2 billion).[679]

Many other significant costs would be incurred in any scenario (high level waste disposal; converting waste to fuel non-existence IFRs, etc).

Some of the relevant facilities are identified by Pangea-successor ARIUS:[680]

- ARIUS proposes transport by purpose-built ships;
- ARIUS proposes a dedicated sea terminal in Australia to provide port facilities;
- ARIUS proposes a dedicated rail system for transport from a port inland to a repository site.
- Support and maintenance facilities for the ships, rail locomotives, rolling stock and transport packages.

ARIUS states: "Depending on the chosen location, road, rail or port facilities may already exist. For a large repository project, however, it could be preferable and affordable to implement dedicated facilities."[681] ARIUS goes on to say: "This also increases the “added-value” of the project to Australia."

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[677] http://decarbonisesa.com/2012/02/22/a-matter-of-waste-latest-in-the-sacome-series/
[678] http://theconversation.com/royal-commission-into-nuclear-will-open-a-world-of-possibilities-37363
[679] www.world-nuclear.org/info/Country-Profiles/Countries-G-N/Japan--Nuclear-Fuel-Cycle/
[680] http://nuclearrc.sa.gov.au/app/uploads/2015/08/Arius-Association-13-07-2015.pdf

[681] http://nuclearrc.sa.gov.au/app/uploads/2015/08/Arius-Association-13-07-2015.pdf

However, dedicated facilities would obviously add significantly to the costs rather than the "added-value".

ARIUS states: "The charges to customers that would cover all such costs are easily within the range that client countries would be willing to pay for the services provided. This is a result of the enormous economies of scale that are apparent at most stages in the process." No evidence is provided to support the claim; it is wishful thinking. Costs in the tens of billions of dollars are certain; revenue is not certain.

Other costs might be incurred depending on the nature of the project − e.g. waste processing or conditioning facilities.

4.5 What are the specific models and case studies that demonstrate the best practice for the establishment, operation and regulation of facilities for the storage or disposal of nuclear or radioactive waste? What are the less successful examples? Where have they been implemented in practice? What new methods have been proposed? What lessons can be drawn from them?
4.8 Bearing in mind the measures that would need to be taken in design and siting, what risks for health and safety would be created by establishing facilities to manage, store and dispose of nuclear or radioactive waste? What needs to be done to ensure that risks do not exceed safe levels? Can anything be done to better understand those risks?
4.9 Bearing in mind the measures that would need to be taken in design and siting, what environmental risks would the establishment of such facilities present? Are there strategies for managing those risks? If not, what strategies would need to be developed? How would any current approach to management need to be changed or adapted?

The above questions are addressed under the following subheadings:
- 'Best practice' and 'less successful examples'
- Hazards associated with high level nuclear waste
- WIPP − explosion in the world's only deep geological repository

'Best practice' and 'less successful examples'

There are no operating repositories for high level nuclear waste. The one and only deep geological repository for intermediate level waste − the Waste Isolation Pilot Plant in the USA − has been a spectacular failure. It is discussed in detail below.

Finland and Sweden are the countries most advanced with deep geological repository projects. Plans for new reactors in Finland are being complicated by the inability of the proposed repository to accommodate any additional waste. Posiva Oy, a joint venture between TVO and Fortum, plans a deep geological repository on Olkiluoto Island but those plans do not include accommodation for spent fuel from any new plants such as the one proposed by the Fennovoima consortium. Posiva, TVO and Fortum have repeatedly said they will not accept Fennovoima as a partner. Posiva President Reijo Sundell said in 2012: "We're not trying to be nasty. But the simple fact is that there is not enough room. We can't expand the site under the sea. We can't create another deeper level because then it might not withstand the pressure of an ice age. And we can't build a shallower level because the underground water there is saltier and therefore more corrosive."[682] Making the Olkiluoto bedrock repository bigger to accommodate waste from additional reactors would cost about 200 million euros, whereas building a separate facility would cost far more.[683]

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[682] 24 Jan 2012, 'Posiva: No room for Fennovoima waste in nuclear cave', http://yle.fi/uutiset/posiva_no_room_for_fennovoima_waste_in_nuclear_cave/5295682
[683] www.world-nuclear.org/info/Country-Profiles/Countries-A-F/Finland/

Plans for a high level waste repository at Yucca Mountain in Nevada, USA, were abandoned in 2009 (although attempts are being made to revive the project). Over 20 years of work was put into the repository plan, and over A$10 billion spent. The repository plan was controversial and subject to scandals including one involving the falsification of safety data in relation to groundwater modeling. Studies found that Yucca Mountain could not meet the existing radiation protection standards in the long term and subsequent moves by the US Environmental Protection Agency to weaken radiation protection standards generated controversy.[684]

Some of the problems dealing with radioactive waste in the US are summarised by Pangea-successor ARIUS:[685]
USA: politics has heavily influence the hugely expensive and as yet unsuccessful repository projects. Unrealistic setting of target dates by politicians led to unnecessary pressures on technical work, failure to meet deadlines and loss of confidence in the implementer (USDOE). Political dealings then led to a poorly justified selection of Yucca Mountain in Nevada and further political deals then led to the multi-billion project there being declared as not workable by the present administration.

In Australia, the management of radioactive waste during the Maralinga 'clean up' in the late 1990s was deeply flawed (discussed in section 1.9). Further, the sorry history of the flawed and failed attempts by successive federal governments to impose a national radioactive waste facility at sites in SA and the NT highlights the complexity and contest that surrounds this issue.

There is no end in sight to Japan's efforts to establish a repository for high-level nuclear waste. The Nuclear Waste Management Organisation was set up in October 2000 by the private sector to progress plans for disposal. Municipalities were invited to indicate whether they were interested in hosting a repository. Only the town of Toyo in western Japan indicated interest − but the town's application was quickly withdrawn after the local population expressed strong opposition. Now, the Japanese government intends to use a top-down approach, identifying "scientifically promising locations" first and then discussing options with local governments. The new policy was approved by Cabinet in May 2015. The revised policy does not specify a timeframe for building a repository. The cost of building a repository is estimated at ¥3,500 billion.[686]

The Science Council of Japan has criticized the government for being "irresponsible toward future generations" by seeking to restart reactors without a decision on a waste disposal site. The council says that finding a site will be difficult "given that public trust in the government, power companies and scientists has been lost" because of the Fukushima disaster.[687]

Germany's efforts to manage nuclear waste have been littered with controversy, scandals, and technical failures − a salutary lesson for Australia given that Germany has far more nuclear experience and expertise than Australia. One of the technical failures is the Asse repository for low- and intermediate-level waste. Water intrusion has caused great damage and plans are being developed to exhume 126,000

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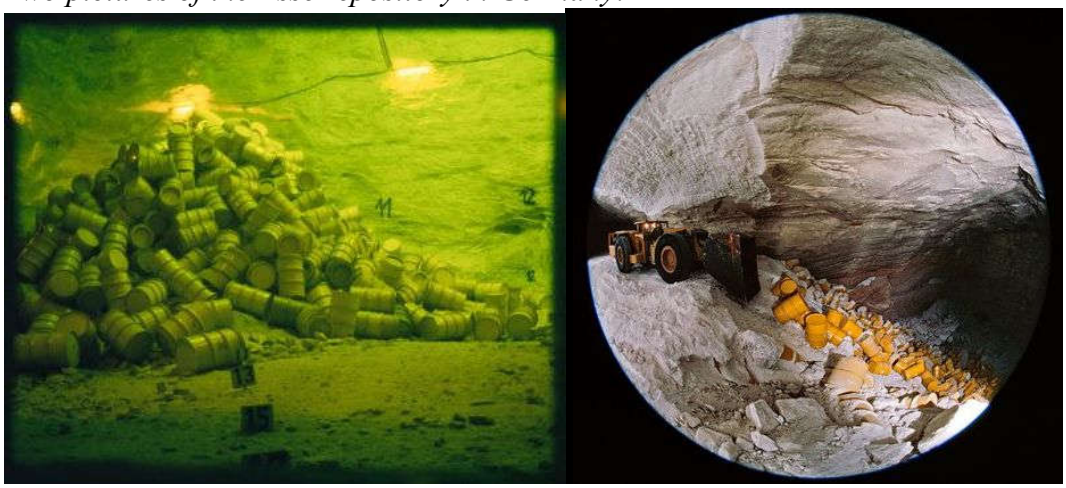
[684] Nuclear Information & Resource Service, www.nirs.org/radwaste/yucca/yuccahome.htm
[685] http://nuclearrc.sa.gov.au/app/uploads/2015/08/Arius-Association-13-07-2015.pdf

[686] WNA, Japan's Nuclear Fuel Cycle, updated May 2015, www.world-nuclear.org/info/Country-Profiles/Countries-G-N/Japan--Nuclear-Fuel-Cycle/
[687] 22 Feb 2015, 'Editorial: Nuclear waste disposal problem', www.japantimes.co.jp/opinion/2015/02/22/editorials/nuclear-waste-disposal-problem/

barrels of waste. The exhumation will be technically challenging and possibly hazardous, it will cost between €4 billion and €10 billion, and it could take up to 30 years.[688]

Two pictures of the Asse repository in Germany:



The protracted and unsuccessful efforts to manage nuclear waste in the UK are detailed in the NFCRC submission written by Jean McSorley, for the Conservation Council of SA, the Australian Conservation Foundation, and Friends of the Earth (Adelaide). Failures include unsuccessful efforts to establish a high level waste repository, reprocessing failures (e.g. THORP), the unsuccessful SMP MOX plant, a stockpile of 100+ tonnes of civil plutonium, etc.

The explosion of a liquid high level nuclear waste tank at Chelyabinsk in the Soviet Union on 29 September 1957 is the worst accident involving nuclear waste.[689] It led a "significant release of radioactive material to the environment" according to the International Atomic Energy Agency. It was rated Level 6 ('Serious Accident') on the 7-point International Nuclear Event Scale. Liquid high level wastes were stored in underground steel tanks in concrete trenches, surrounded by coolers. Failure to repair a cooling system in one of the tanks led to an increase in temperature and eventually − after about one year − to a chemical explosion. The contamination was "very serious" according to Soviet scientists; the total release was of the order of 740,000 terabecquerels (20 megacuries) with about 90% deposited in the immediate area and 10% widely dispersed. The accident resulted in long-term contamination of more than 800 sq kms, primarily with caesium-137 and strontium-90; this area is referred to as the East-Ural Radioactive Trace. Over 10,000 people were evacuated in the 18 months following the accident. Over 1,000 sq kms of land in Chelyabinsk province and Sverdlovsk province were removed from agricultural use. Soviet scientists noted that clean-up measures were "inadequately effective" and produced "comparatively poor results". Nevertheless, all but 220 sq kms were returned to agricultural use between 1961 and 1978. It is estimated that direct exposure to radiation from the accident caused at least 200 long-term cancer deaths − although other estimates put the figure significantly higher and others significantly lower.

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[688] Michael Fröhlingsdorf, Udo Ludwig and Alfred Weinzierl, 21 Feb 2013, 'Abyss of Uncertainty: Germany's Homemade Nuclear Waste Disaster', www.spiegel.de/international/germany/germany-weighs-options-for-handling-nuclear-waste-in-asse-mine-a-884523.html

[689] www.bellona.org/articles/articles_2008/kyshtym_memorial
www.iaea.org/Publications/Documents/Infcircs/Others/inf368.shtml
www.johnstonsarchive.net/nuclear/radevents/1957USSR1.html
'Soviets Tell About Nuclear Plant Disaster; 1957 Reactor Mishap May Be Worst Ever', 'The Washington Post', R. Jeffrey Smith, 10 July 1989
http://en.wikipedia.org/wiki/Kyshtym_disaster
www.fas.org/news/russia/1995/fbust037_95011.htm
www.iaea.org/Publications/Factsheets/English/ines.pdf

Hazards associated with high level nuclear waste

Spent fuel / high level waste is extraordinarily radioactive and hazardous. It takes about 300,000 years for the radioactivity of spent fuel to decline to that of the original uranium ore.[690] For the high level waste stream from reprocessing (from which plutonium and uranium have been removed), it takes about 10,000 years for the radioactivity to decline to that of the uranium ore body.[691]

Writing in *Australian Geologist*, Professor John Veevers from Macquarie University notes the serious public health and environmental risks associated with a high level nuclear waste repository:
"Tonnes of enormously dangerous radioactive waste in the northern hemisphere, 20,000 kms from its destined dump in Australia where it must remain intact for at least 10,000 years. These magnitudes − of tonnage, lethality, distance of transport, and time − entail great inherent risk."[692]

Pangea-successor ARIUS notes some of the technical challenges:[693]
In general, repositories are held to stringent safety standards defined both internationally and by national radiation safety regulatory authorities. These standards require a high level of containment of the emplaced wastes, as even a small fraction returning to the biosphere can result in violating the standards. It must be demonstrated that repositories will continue to meet these standards for an extremely long time and national regulations often define different practical yardsticks and measures for different times in the future. This will require developing an unprecedented level of confidence in our ability to understand the long-term future performance of the repository system.

In a detailed 2010 report, Dr Helen Wallace summarises numerous potential problems with deep geological storage of nuclear waste:[694]

- Corrosion of copper or steel canisters and overpacks.
- The effects of intense heat generated by radioactive decay, and of chemical and physical disturbance due to corrosion, gas generation and biomineralisation, could impair the ability of backfill material to trap some radionuclides.
- Build-up of gas pressure in the repository, as a result of the corrosion of metals and/or the degradation of organic material, could damage the barriers and force fast routes for radionuclide escape through crystalline rock fractures or clay rock pores.
- Poorly understood chemical effects, such as the formation of colloids, could speed up the transport of some of the more radiotoxic elements such as plutonium.
- Unidentified fractures and faults, or poor understanding of how water and gas will flow through fractures and faults, could lead to the release of radionuclides in groundwater much faster than expected.
- Excavation of the repository will damage adjacent zones of rock and could thereby create fast routes for radionuclide escape.
- Future generations, seeking underground resources or storage facilities, might accidentally dig a shaft into the rock around the repository or a well into contaminated groundwater above it.

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[690] https://theconversation.com/the-case-for-nuclear-power-despite-the-risks-41552
[691] Switkowski Review, 2006, Uranium Mining, Processing and Nuclear Energy Review, http://pandora.nla.gov.au/tep/66043
[692] J.J. Veevers, 'Disposal of British RADwaste at home and in antipodean Australia', http://web.archive.org/web/20120410062832/http:/eps.mq.edu.au/media/veevers1.htm
[693] http://nuclearrc.sa.gov.au/app/uploads/2015/08/Arius-Association-13-07-2015.pdf
[694] Dr Helen Wallace for Greenpeace International, Sept 2010, 'Rock Solid? A scientific review of geological disposal of high-level radioactive waste', www.greenpeace.org/eu-unit/en/Publications/2010/rock-solid-a-scientific-review/

- Future glaciations could cause faulting of the rock, rupture of containers and penetration of surface waters or permafrost to the repository depth, leading to failure of the barriers and faster dissolution of the waste.
- Earthquakes could damage containers, backfill and the rock.

Dr Wallace identifies the following unresolved issues:
- the high likelihood of interpretative bias in the safety assessment process because of the lack of validation of models, the role of commercial interests and the pressure to implement existing road maps despite important gaps in knowledge. Lack of (funding for) independent scrutiny of data and assumptions can strongly influence the safety case.
- lack of a clearly defined inventory of radioactive wastes, as a result of uncertainty about the quantities of additional waste that will be produced in new reactors, increasing radioactivity of waste due to the use of higher burn-up fuels, and ambiguous definitions of what is considered as waste.
- the question of whether site selection and characterisation processes can actually identify a large enough volume of rock with sufficiently favourable characteristics to contain the expected volume of wastes likely to be generated in a given country.
- tension between the economic benefits offered to host communities and long-term repository safety, leading to a danger that concerns about safety and impacts on future generations may be sidelined by the prospect of economic incentives, new infrastructure or jobs.
- potential for significant radiological releases through a variety of mechanisms, involving the release of radioactive gas and/or water due to the failure of the near-field or far-field barriers, or both.
- significant challenges in demonstrating the validity and predictive value of complex computer models over long timescales.
- risk of significant escalation in repository costs.

The UK group Nuclear Waste Advisory Associates (NWAA) published an Issues Register in 2010 listing 100 issues which need resolution before any kind of safety case can be made for deep geological disposal.[695] The register considers potential problems and data gaps in the following categories:

Gases
Release of Hydrogen Gas
Radioactive Carbon – High Doses within Short Timescale
Site Considerations
Gases and the Site Selection
Availability of Necessary Site Data
Groundwater flow and transport
Gas/Groundwater Flow
Construction Issues
Mechanical Questions - Constructability issues
Worker Doses
The Waste Package and Repository Components
The Waste Package Itself
The Components of the Waste Facility
High Level Wastes
Clay
Interactions Between the Facility and the Surrounding Rock
Chemistry and Contamination Levels
Risk Predictions Not Reliable

[695] Nuclear Waste Advisory Associates Issues Register, March 2010, www.nuclearwasteadvisory.co.uk/wp-content/uploads/2011/06/NWAA-ISSUES-REGISTER-COMMENTARY.pdf

Calculating Contamination Levels
Solubility of Chemicals holding Radionuclides
Oxygen
Large Chemicals – 'Colloids'
Behaviour in Natural Systems
Containment in Alkaline System – cf Detriment to Clay
'Ionic Strength' Effect – Salty Water
Cellulose Breakdown Products + Solubility Increases
Sorption
Plutonium and Uranium-235 and Nuclear Energy
Possible Impact Nuclear Energy Chain Reaction
The Nuclear Weapon Dilemma
Biota
Living Things
Microbes
Timescales

The UK Nuclear Decommissioning Authority has developed an Issues Register listing and discussing a large number of relevant issues that require consideration.[696]

A January 2015 article discusses recent debates regarding copper corrosion:[697]

> **Corrosion**
> To illustrate the sorts of issues being raised by Rock Solid, NWAA and others, one of the many issues raised was a particular problem with copper corrosion which has been raised by some recent research.
> The KBS-3V disposal concept using copper containers is one of the current disposal concepts under consideration by RWM, for High Level Waste/Spent Fuel (HLW/SF) in higher strength rock. (If the host rock for a DGR were clay then the Swiss NAGRA concept would be used and the German system if the host rock were salt).
> Both SKB in Sweden and Posiva in Finland have selected the KBS-3V disposal concept as their reference design for use in a spent fuel repository. The KBS-3V disposal concept has been developed over a period of nearly four decades. In this concept, vertical copper canisters are used to store spent fuel, in vertical deposition holes. Adjacent to the canister Bentonite clay would be used to contain the canisters and retard any potential radionuclide migration. Bentonite is also used to backfill the deposition tunnels.
> The copper canisters are supposed to be corrosion resistant, but in July 2009 Hultquist et al published research which suggested that a copper wall thickness of one metre would be required for long-term (100,000 years) durability. It is not clear how such a wall thickness would be either logistically or economically achievable. (6)
> The Swedish NGO, MKG explains that after the emplacement of the canisters and clay the oxygen in the repository is quickly consumed by bacteria and chemical processes. The fundamental assumption in the KBS method is that very little corrosion takes place in an oxygen-free environment. The canister walls are 5 centimetres thick and only a millimetre or two of the copper is supposed to corrode in a million years.
> Now new research shows that once copper begins to corrode, the process can proceed quickly through so-called pitting, which gives pox-mark indentations in the surface. The risk of pitting

[696] www.nda.gov.uk/rwm/issues/navigating-your-way-around-the-issues-register/
[697] www.no2nuclearpower.org.uk/nuclearnews/NuClearNewsNo70.pdf

has led critical researchers to fear that the copper canisters may start to leak after only some hundreds of years — instead of after hundreds of thousands of years.
In November 2009 after various papers by Hultquist et al, the Swedish Council for Nuclear Waste, an independent scientific committee which advises the Government, organised a workshop. The conclusions of the expert panel invited to comment on the issues raised were not categorical. The Council states that:
"...mechanisms of copper corrosion in oxygen-free water must be investigated experimentally to determine whether corrosion of copper by hydrogen evolution can take place in pure, deionized, oxygen-free water and in groundwater with bentonite." (7)
Then in 2011 **t**he Swedish Radiation Safety Authority (SSM) published research which in principal reproduced parts of Hultquist at al. Exposure of copper in pure anoxic water (depleted of dissolved oxygen) resulted in a measureable gas production rate. The most obvious explanation for the results in this work is consequently that corrosion of copper occurs in pure anoxic water. (8)
In 2012 SSM explained that the copper canisters will need to meet to two completely different environments over the life of the geological disposal facility;
• an initial period of several hundreds of years when copper is exposed to gaseous corrosion
• and then a period when it is exposed to aqueous corrosion
From a corrosion point of view the first 1000 years are the most critical for the copper canister since pure, or phosphorus alloyed copper, is not designed to cope with corrosion at elevated temperatures. The outer copper surface temperature is expected to reach 100°C within some decades after closure of the repository and then slowly cool down to around 50°C after 1000 years.
SSM criticises SKB for only looking at oxygen when assessing gaseous corrosion. It says "*This simple model has no scientific support since several corrosive trace gases, such as sulphurous and nitrous compounds, operates together with water molecules (moisture) and the corrosion product consists mostly of oxides and hydroxides derived from water molecules. These trace gases are known to have an accelerating effect on copper corrosion. Any corrosion model describing the gaseous copper corrosion period must therefore be based on experimental data*." (9)
In 2013, SSM commissioned Hultquist and others to carry out further research. This indicated that corrosion of copper in anoxic water involves a mechanism in which hydrogen atoms present in water molecules form hydrogen gas which partly dissociate and diffuse into the copper metal as hydrogen atoms. (10)
In September 2014 SKB submitted a progress report to SSM on Copper Corrosion. SKB now admits that theoretically copper can corrode in anoxic water and that there are indications that the process does occur on the surface. But SKB claims that the corrosion stops very soon after starting and that hydrogen measured over longer time-scales comes from inside the copper and not from a continued corrosion process. Unfortunately SKB had no evidence to support this assertion. And according to microbiologist Karsten Pedersen in Gothenburg, who carried out the study for SKB, it is possible to interpret the results in different ways. (11)
SKB claimed that it was now scientifically proven that even if copper can react with oxygen-free water, this is only a short-lived surface effect. Hence, the corrosion process will not be a threat to the long-term safety of the planned repository for spent nuclear fuel at Forsmark.
This ongoing scientific debate on just one of many unresolved issues surely raises a question-mark over whether it will ever be possible to produce an adequate robust safety case in order to proceed with burying nuclear waste underground.
6. "Water Corrodes Copper" G. Hultquist et al [July 2009 – (online)] Catal Lett (2009) 132: 311–316: Received: 29 June 2009 - Accepted: 19 July 2009 (Published online: 28 July 2009) Springer Science+Business Media, LLC 2009
http://www.mkg.se/uploads/Water_Corrodes_Copper_-_Catalysis_Letters_Oct_2009_-_Hultquist_Szakalos_et_al.pdf

7. Nuclear Waste State-of-the-Art Report 2010 — Challenges for the Final Repository Program, Swedish Council for Nuclear Waste, Stockholm, 2010.
http://www.government.se/sb/d/574/a/150543 (quoted in Managing Spent Fuel from Nuclear Power Reactors: Experience and Lessons from Around the World, IPFM, September 2011 http://www.fissilematerials.org/library/rr10.pdf
8. 2011:34 Evolution of hydrogen by copper in ultrapure water without dissolved oxygen, by Richard Becker and Hans-Peter Hermansson
http://www.stralsakerhetsmyndigheten.se/Publikationer/Rapport/Avfall-transport-fysiskt-skydd/2011/201134/
9. Technical Note: Corrosion of Copper Canister 2012:17, SSM
http://www.stralsakerhetsmyndigheten.se/Publikationer/Rapport/Avfall-transport-fysiskt-skydd/2012/201217/
10. 2013:07 Corrosion of copper in distilled water without molecular oxygen and the detection of produced hydrogen, G. Hultquist, M.J. Graham, O. Kodra, S. Moisa, R. Liu, U. Bexell and J.L. Smialek. http://www.stralsakerhetsmyndigheten.se/Publikationer/Rapport/Avfall-transport-fysiskt-skydd/2013/201307/
11. Swedish Radio 3rd Oct 2014
http://sverigesradio.se/sida/artikel.aspx?programid=406&artikel=5981167

WIPP − explosion in the world's only deep geological repository

No deep underground repositories for high level nuclear waste exist, however there is one deep underground repository for long lived intermediate-level nuclear waste − the Waste Isolation Pilot Plant (WIPP) in the US state of New Mexico.

On 5 February 2014, a truck hauling salt caught fire at WIPP. Six workers were treated at the Carlsbad hospital for smoke inhalation, another seven were treated at the site, and 86 workers were evacuated. A March 2014 report by the US Department of Energy identified the root cause of the fire as the "failure to adequately recognize and mitigate the hazard regarding a fire in the underground." In 2011, the Defense Nuclear Facilities Safety Board, an independent advisory board, reported that WIPP "does not adequately address the fire hazards and risks associated with underground operations."[698]

In a separate incident, on 14 February 2014 a heat-generating chemical reaction ruptured one of the barrels stored underground at WIPP, and this was followed by a failure of the filtration system meant to ensure that radiation did not reach the outside environment. Twenty-two workers were exposed to low-level radiation, the total cost to fix up the problems will exceed $500 million, and WIPP will be shut for at least four years.[699]

A US government report blamed the barrel rupture and radiation release on the operator and regulator of WIPP, noting their "failure to fully understand, characterize, and control the radiological hazard ... compounded by degradation of key safety management programs and safety culture."[700]

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[698] 6 June 2014, 'Fire and leaks at the world's only deep geological waste repository', Nuclear Monitor #787, www.wiseinternational.org/node/4245

[699] 27 Nov 2014, 'New Mexico nuclear waste accident a 'horrific comedy of errors' that exposes deeper problems', *The Ecologist*, www.theecologist.org/News/news_analysis/2642182/new_mexico_nuclear_waste_accident_a_horrific_comedy_of_errors_that_exposes_deeper_problems.html

[700] US Dept of Energy, Office of Environmental Management, April 2014, 'Accident Investigation Report: Phase 1: Radiological Release Event at the Waste Isolation Pilot Plant on February 14, 2014', http://energy.gov/em/downloads/radiological-release-accident-investigation-report

A safety analysis conducted before WIPP opened predicted that one radiation release accident might occur every 200,000 years.[701] On the basis of real-world experience, that estimate needs to be revised upwards to over 13,000 accidents over a 200,000 year period.

A troubling aspect of the WIPP problems is that complacency and cost-cutting set in just 10−15 years after the repository opened. Earl Potter, a lawyer who represented Westinghouse, WIPP's first operating contractor, said:[702]

"At the beginning, there was an almost fanatical attention to safety. I'm afraid the emphasis shifted to looking at how quickly and how inexpensively they could dispose of this waste." Likewise, Rick Fuentes, president of the Carlsbad chapter of the United Steelworkers union, said: "In the early days, we had to prove to the stakeholders that we could operate this place safely for both people and the environment. After time, complacency set in. Money didn't get invested into the equipment and the things it should have."

Complacency and cost-cutting set in just 10−15 years after WIPP opened. The half-life of plutonium-239, one of the components in the WIPP waste, is 24,100 years.

The following articles provide more information:

> **One deep underground dump, one dud**
> *Nuclear Monitor #801, 9 April 2015*
> *www.wiseinternational.org/nuclear-monitor/801/one-deep-underground-dump-one-dud*
> There is only one deep underground dump (DUD) for nuclear waste anywhere in the world, and it's a dud. The broad outline of this dud DUD story is simple and predictable: over a period of 10−15 years, high standards gave way to complacency, cost-cutting and corner-cutting.
> The Waste Isolation Pilot Plant (WIPP) in New Mexico, USA, is a burial site for long-lived intermediate-level waste from the US nuclear weapons program. More than 171,000 waste drums have been stored in salt caverns 2,100 feet (640 metres) underground since WIPP opened in 1999.
> Earl Potter, a lawyer who represented Westinghouse, WIPP's first operating contractor, said: "At the beginning, there was an almost fanatical attention to safety. I'm afraid the emphasis shifted to looking at how quickly and how inexpensively they could dispose of this waste."[1]
> Likewise, Rick Fuentes, president of the Carlsbad chapter of the United Steelworkers union, said: "In the early days, we had to prove to the stakeholders that we could operate this place safely for both people and the environment. After time, complacency set in. Money didn't get invested into the equipment and the things it should have."[1]
> Before WIPP opened, sceptical locals were invited to watch experiments to assure them how safe the facility would be. Waste containers were dropped from great heights onto metal spikes, submerged in water and rammed by trains.[1] Little did they know that a typo and kitty litter would be the undoing of WIPP.
> On 14 February 2014, a drum rupture spread contaminants through about one-third of the underground caverns and tunnels, up the exhaust shaft, and into the outside environment. Twenty-two people were contaminated with low-level radioactivity.
> A Technical Assessment Team convened by the US Department of Energy (DoE) has recently released a report into the February 2014 accident.[2] The report concludes that just one drum was

[701] Matthew Wald, 29 Oct 2014, 'In U.S. Cleanup Efforts, Accident at Nuclear Site Points to Cost of Lapses', www.nytimes.com/2014/10/30/us/in-us-cleanup-efforts-accident-at-nuclear-site-points-to-cost-of-lapses.html

[702] Patrick Malone, 14 Feb 2015, 'Repository's future uncertain, but New Mexico town still believes', www.santafenewmexican.com/special_reports/from_lanl_to_leak/repository-s-future-uncertain-but-new-mexico-town-still-believes/article_38b0e57b-2d4e-5476-b3f5-0cfe81ce94cc.html

the source of radioactive contamination, and that the drum rupture resulted from internal chemical reactions.

Chemically incompatible contents in the drum − nitrate salt residues, organic sorbent and an acid neutralization agent − supported heat-generating chemical reactions which led to the creation of gases within the drum. The build-up of gases displaced the drum lid, venting radioactive material and hot matter that further reacted with the air or other materials outside the drum to cause the observed damage.

Kitty litter

The problems began at Los Alamos National Laboratory (LANL), where the drum was packed. One of the problems at LANL was the replacement of inorganic absorbent with an organic absorbent − kitty litter. Carbohydrates in the kitty litter provided fuel for a chemical reaction with metal nitrate salts being disposed of.

The switch to kitty litter took effect on 1 August 2012. LANL staff were explicitly directed to "ENSURE an organic absorbent (kitty litter) is added to the waste" when packaging drums of nitrate salts. LANL's use of organic kitty litter defied clear instructions from WIPP to use an inorganic absorbent.[3]

Why switch from inorganic absorbent to organic kitty litter? The most likely explanation is that the problem originated with a typo in notes from a meeting at LANL about how to package "difficult" waste for shipment to WIPP − and the subsequent failure of anyone at LANL to correct the error. In email correspondence, Mark Pearcy, a member of the team that reviews waste to ensure it is acceptable to be stored at WIPP, said: "General consensus is that the 'organic' designation was a typo that wasn't caught."[3]

LANL officials have since acknowledged several violations of its Hazardous Waste Facility Permit including the failure to follow proper procedures in making the switch to organic litter, and the lack of follow-up on waste that tests showed to be highly acidic.[4]

Ongoing risks

The heat generated by the rupture of drum #68660 may have destabilized up to 55 other drums that were in close proximity. A June 2014 report by LANL staff based at WIPP said the heat "may have dried out some of the unreacted oxidizer-organic mixtures increasing their potential for spontaneous reaction. The dehydration of the fuel-oxidizer mixtures caused by the heating of the drums is recognized as a condition known to increase the potential for reaction."[5]

The Albuquerque Journal reported on March 15 that 368 drums with waste comparable to drum #68660 are stored underground at WIPP − 313 in Panel 6, and 55 in Room 7 of Panel 7, the same room as drum #68660. WIPP operators are trying to isolate areas considered to be at risk with chain links, brattice cloth to restrict air flow, mined salt buffers and steel bulkheads. Efforts to shut off particular rooms and panels have been delayed and complicated by radiological contamination, limitations on the number of workers and equipment that can be used due to poor ventilation, and months of missed maintenance that followed the February 2014 accident.[6]

An *Associated Press* report states that since September 2012, LANL packed up to 5,565 drums with organic kitty litter. Of particular concern are 16 drums with highly acidic contents as well as nitrate salts. Of those 16 drums, 11 are underground at WIPP (one of them is drum #68660), and the other five are in temporary storage at a private waste facility in Andrews, Texas.[4]

Freedom of Information revelations

The Santa Fe *New Mexican* newspaper has revealed further details about problems before and after the February 2014 accident, based on material from a Freedom of Information Act request.[3]

The *New Mexican* reports that LANL workers came across a batch of waste that was highly acidic, making it unsafe for shipping. A careful review of treatment options should have followed, but instead LANL and its contractors took shortcuts, adding acid neutralizer as well as kitty litter to absorb excess liquid. The wrong neutralizer was used, exacerbating the problem.[3]

One of these waste drums was #68660. Documents accompanying the drum from LANL to WIPP made no mention of the high acidity or the neutralizer, and they said that it contained an inorganic absorbent.[3]

The decision to take shortcuts was likely motivated by pressure to meet a deadline to remove waste from an area at LANL considered vulnerable to fire. Meeting the deadline would have helped LANL contractors' extend their lucrative contracts to package waste at LANL and transport it to WIPP.[3]

For two years preceding the February 2014 incident, LANL refused to allow inspectors conducting annual audits for the New Mexico Environment Department (NMED) inside the facility where waste was treated, saying the auditors did not have appropriate training to be around radioactive waste. The NMED did not insist on gaining access because, in the words of a departmental spokesperson, it was "working on higher priority duties at the time that mandated our attention."[3]

There were further lapses after the drum rupture. The *New Mexican* reported:

"Documents and internal emails show that even after the radiation leak, lab officials downplayed the dangers of the waste − even to the Carlsbad managers whose staff members were endangered by its presence − and withheld critical information from regulators and WIPP officials investigating the leak. Internal emails, harshly worded at times, convey a tone of exasperation with LANL from WIPP personnel, primarily employees of the Department of Energy and Nuclear Waste Partnership, the contractor that operates the repository."[3]

Several months after the rupture of drum #68660, an LANL chemist discovered that the contents of the drum matched those of a patented explosive. Personnel at WIPP were not informed of the potential for an explosive reaction for nearly another week − and they only learned about the problem after a DoE employee leaked a copy of the chemist's memo to a colleague in Carlsbad the night before a planned entry into the room that held the ruptured drum. That planned entry was cancelled. Workers in protective suits entered the underground area several days later to collect samples.[3]

"I am appalled that LANL didn't provide us this information," Dana Bryson from DoE's Carlsbad Field Office wrote in an email when she learned of the memo.[3]

The DoE employee who first alerted WIPP personnel to the threat was reprimanded by the DoE's Los Alamos Site Office for sharing the information.[3]

Contamination

Inevitably the clean-up has faced problems due to radioactive contamination in the underground panels and tunnels, and delays in routine underground maintenance because of the contamination. The Santa Fe *New Mexican* reported on some of these problems:

"In October, when a fan was tested for the first time since the accident, it kicked up low levels of radioactive materials that escaped from the mine. Waste drums that normally would have been permanently disposed of within days of their arrival at WIPP instead were housed in an above-ground holding area for months and leaked harmful but nonradioactive vapors that sickened four workers. A chunk of the cavern's ceiling crashed to the ground after the contamination delayed for months the routine bolting that would have stabilized the roof."[1]

Another problem is that workers are entering underground areas that are not being monitored for carcinogenic volatile organic compounds. Monitoring of these compounds, a condition of WIPP's permit from the state of New Mexico, has not been taking place since February 2014 because of limited access to contaminated underground areas.[5]

Don Hancock from the Southwest Research and Information Center said:

"They have no intention of starting to do the volatile organic compound monitoring in the underground at least until January of 2016. They fully intend to keep sending workers into the underground with no intention of following this requirement. It's in violation of the permit, and the Environment Department should say so."[5]

Fines

The NMED has fined the DoE US$54 million (€49.2m). The Department identified 13 violations at WIPP, and imposed penalties of US$17.7 million (€16.1m). The Department identified 24 violations at LANL, and imposed penalties of US$36.6 million (€33.3m).[7] The DoE is appealing the fines.[8]

The DoE says that any state fines it pays for the WIPP accident will come from money appropriated to clean up nuclear weapons sites in New Mexico. A 2016 budget year summary presented in February by DoE's Office of Environmental Management says: "Any fines and penalties assessed on the EM [environmental management] program would be provided by cleanup dollars, resulting in reduced funding for cleanup activities."[8]

NMED Secretary Ryan Flynn responded:

"Essentially, DoE is threatening to punish states by doing less cleanup work if states attempt to hold it accountable for violating federal and state environmental laws. States like New Mexico welcome federal facilities into our communities with the understanding that these facilities will respect the health and safety of our citizens by complying with federal and state laws."[8]

The NMED is working on a new compliance order that could include fines of more than US$100 million (€91.1m). Flynn said:

"We've indicated all along that if DoE is willing to take accountability for the events that caused the release and work with the state then we'd be willing to release them from any further liability at Los Alamos and WIPP. If DoE is not willing to take accountability for what's occurred, then they are going to face significant additional penalties."[9]

A February 22 editorial in the *Albuquerque Journal* states:

"It would behoove the DoE to quit poisoning the well when it doesn't have another option for disposing of this kind of waste underground. ... So the DOE should start paying up and playing fair with the only game in town."[10]

Greg Mello from the Los Alamos Study Group said that an increase in weapons spending proposed by the Obama administration would pay "all the NMED-proposed fines a few times over."[8]

Clean-up costs

Costs associated with the February 2014 accident include clean-up costs, fines, and costs associated with managing the backlog of waste at other sites until it can be sent to WIPP. Total costs will be at least US$500 million (€455m).[1]

WIPP is unlikely to be fully operational until at least 2018 according to federal Energy Secretary Ernest Moniz. "We are targeting 2018 but I have to admit that that remains a little uncertain; the key project is the new ventilation system and that is still undergoing engineering analysis," Moniz said in February.

Don Hancock doubts that the 2018 timeline can be met. Salt mines exist across the world, he said, but reopening a contaminated salt mine following a radiological release is unprecedented and the government has no model to follow.[11]

Earl Potter, the former Westinghouse lawyer with a long association with WIPP, told the *New Mexican* that he doubted whether WIPP could continue if another radiation leak happened during the recovery process. "We can survive one," he said, "but two, I don't think so."[1]

References:

1. Patrick Malone, 14 Feb 2015, 'Repository's future uncertain, but New Mexico town still believes', www.santafenewmexican.com/special_reports/from_lanl_to_leak/repository-s-future-uncertain-but-new-mexico-town-still-believes/article_38b0e57b-2d4e-5476-b3f5-0cfe81ce94cc.html

2. Technical Assessment Team, March 2015, 'Investigation of Incident at Waste Isolation Pilot Plant'
Summary:
http://energy.gov/sites/prod/files/2015/03/f20/TAT_Fact_sheet%2032615%20FINAL.pdf
Full report: http://energy.gov/sites/prod/files/2015/03/f20/MARCH%202015%20-%20FINAL%20TECHNICAL%20ASSESSMENT%20TEAM%20REPORT.pdf

3. Patrick Malone, 15 Nov 2014, 'LANL officials downplayed waste's dangers even after leak', www.santafenewmexican.com/special_reports/from_lanl_to_leak/lanl-officials-downplayed-waste-s-dangers-even-after-leak/article_54d7f3d2-8c99-5793-8c17-c4bdb0b72ef1.html

4. Jeri Clausing / Associated Press, 4 July 2014, 'U.S. lab admits violating nuke-waste permit', www.sltrib.com/sltrib/world/58150394-68/waste-lab-wallace-acidic.html.csp
5. Patrick Malone, 29 Nov 2014, 'Emails raise questions about risks to WIPP workers sent underground', www.santafenewmexican.com/news/local_news/emails-raise-questions-about-safety-of-wipp-workers-in-underground/article_0cb47b4d-5af1-51bc-8cf3-bcf150b3a65e.html
6. Lauren Villagran, 15 March 2015, 'Roof collapses pose safety risk for workers at WIPP', www.abqjournal.com/555711/news/roof-collapses-pose-safety-risk-at-wipp.html
7. WNN, 8 Dec 2014, 'Fines follow WIPP incidents', www.world-nuclear-news.org/RS-Fines-follow-WIPP-incidents-0812147.html
8. Mark Oswald, 20 Feb 2015, 'DOE says any fines for WIPP leak will come from clean-up money', www.abqjournal.com/544461/news/doe-says-any-fines-for-wipp-leak-will-come-from-clean-up-money.html
9. 10 Feb 2015, 'New Mexico Considers More Fines Over Nuke Leak', www.nytimes.com/aponline/2015/02/10/us/ap-us-nuke-repository-recovery.html?_r=0
10. Albuquerque Journal Editorial Board, 22 Feb 2015, 'Editorial: Balking at fines won't help DOE reach a nuke solution', www.abqjournal.com/544790/opinion/balking-at-fines-wont-help-doe-reach-a-nuke-solution.html
11. Meg Mirshak, 24 March 2015, 'New Mexico group doubts WIPP repository will reopen by deadline, leaving waste stranded at Savannah River Site', http://chronicle.augusta.com/news/metro/2015-03-24/new-mexico-group-doubts-wipp-repository-will-reopen-deadline-leaving-waste

New Mexico nuclear waste accident a 'horrific comedy of errors' that exposes deeper problems

27 Nov 2014, The Ecologist

www.theecologist.org/News/news_analysis/2642182/new_mexico_nuclear_waste_accident_a_horrific_comedy_of_errors_that_exposes_deeper_problems.html

The precise cause of the February 14 accident involving a radioactive waste barrel at the world's only deep geological radioactive waste repository has yet to be determined, but information about the accident continues to come to light.

The Waste Isolation Pilot Plant (WIPP) in New Mexico, USA, is a dump site for long-lived intermediate-level waste from the US nuclear weapons program. More than 171,000 waste containers are stored in salt caverns 2,100 feet (640 metres) underground.

On February 14, a heat-generating chemical reaction − the Department of Energy (DOE) calls it a 'deflagration' rather than an explosion − compromised the integrity of a barrel and spread contaminants through more than 3,000 feet of tunnels, up the exhaust shaft, into the environment, and to an air monitoring approximately 3,000 feet north-west of the exhaust shaft.[1] The accident resulted in 22 workers receiving low-level internal radiation exposure.

Investigators believe a chemical reaction between nitrate salts and organic 'kitty litter' used as an absorbent generated sufficient heat to melt seals on at least one barrel. But experiments have failed to reproduce the chemical reaction, and hundreds of drums of similarly packaged nuclear waste are still intact, said DOE spokesperson Lindsey Geisler. "There's still a lot we don't know", she said.[2]

Terry Wallace from Los Alamos National Laboratory (LANL) said: "LANL did not consider the chemical reactions that unique combinations of radionuclides, acids, salts, liquids and organics might create."[3]

Determining the cause of the accident has been made all the more difficult because the precise composition of the waste in the damaged barrel is unknown.[4,5] A former WIPP official said: "The DOE sites that sent in the waste got careless in documenting what was being shipped in ... The contractors at the sites packing the waste were not exactly meticulous. When we complained to DOE, it was made clear we were just to keep taking the waste and to shut up." [6]

Operations to enable WIPP to reopen will cost approximately US$242 million according to preliminary estimates by the DOE. In addition, a new ventilation system is required which will cost US$65-261 million.[7] Taking into account indirect costs such as delays with the national nuclear weapons clean-up program, the total cost could approach US$1 billion.[4] Further costs could be incurred if the State of New Mexico fines DOE for its safety lapses at WIPP.[5]
The DOE hopes WIPP will reopen in 2016 but the shut-down could extend to 2017 or beyond.[8]

A 'horrific comedy of errors'

British academic Rebecca Lunn, a professor of engineering geosciences, describes how waste repositories would work in a perfect world. "Geological disposal of nuclear waste involves the construction of a precision-engineered facility deep below the ground into which waste canisters are carefully manoeuvred. Before construction of a geological repository can even be considered, an environmental safety case must be developed that proves the facility will be safe over millions of years."[9]
Prof. Lunn's description is far removed from the situation that prevails at WIPP. Robert Alvarez, a former assistant to the energy secretary, said that a safety analysis conducted before WIPP opened predicted accidents such as the February 14 deflagration once every 200,000 years. Yet WIPP has been open for merely 15 years.[5] WIPP is on track for not one but over 13,000 radiation release accidents over a 200,000 year period.
The WIPP accident resulted from a "horrific comedy of errors" according to James Conca, a scientific adviser and WIPP expert: "This was the flagship of the Energy Department, the most successful program it had. The ramifications of this are going to be huge." [4]
The problems began long before February 14, and they extend beyond WIPP. Serious problems have been evident across the US nuclear weapons program. Systemic problems have been evident with DOE oversight.
The problematic role of the National Nuclear Security Administration (NNSA) − a semi-autonomous agency within the DOE − is emphasised in a detailed analysis by investigative journalist Joseph Trento.[6] A DOE official quoted by Trento said a root problem is "the fact that DOE has no real operational control over the NNSA. Under the guise of national security, NNSA runs the contractors, covers up accidents and massive cost overruns and can fire any DOE employee who tries to point out a problem. Because they control so many jobs and contractors, every administration refuses to take them on."
Trento explains the realpolitik:
"The contractor game at NNSA is played this way: Major corporations form LLC's [limited liability companies] and bid for NNSA and DOE contracts. For example, at SRS [Savannah River Site] they bid to clean up waste and get some of the billions of dollars from Obama's first term stimulus money. Things go wrong, little gets cleaned up, workers get injured or exposed to radiation and outraged NNSA management cancels the contract. A new LLC is formed by the same NNSA list of corporate partners and they are asked to bid on a new management contract. The new LLC hires the same workers as the old management company and the process gets repeated again and again. The same mistakes are made and the process keeps repeating itself. These politically connected DOE contractors, responsible for tens of billions of dollars in failed projects and mishandling of the most deadly materials science has created, have been protected by the biggest names in both the Republican and Democratic parties at an enormous cost to the US taxpayers, public health and the environment."

Major deficiencies at Los Alamos National Laboratory

Of immediate relevance to the February 14 WIPP accident are problems at Los Alamos National Laboratory (LANL). The waste barrel involved in the accident was sent from LANL to WIPP. LANL staff approved the switch from an inorganic clay absorbent to an organic material in September 2013. That switch is believed to be one of the causes of the February 14 accident. LANL also approved the use of a neutraliser that manufacturers warned shouldn't be mixed with certain chemicals.[10]

A September 30 report by the DOE's Office of Inspector General identifies "several major deficiencies in LANL's procedures for the development and approval of waste packaging and remediation techniques that may have contributed" to the February 14 WIPP accident.[11]
The report states:
"Of particular concern, not all waste management procedures at LANL were properly vetted through the established procedure revision process nor did they conform to established environmental requirements.
"In our view, immediate action is necessary to ensure that these matters are addressed and fully resolved before TRU [transuranic] waste operations are resumed, or, for that matter, before future mixed radioactive hazardous waste operations are initiated.
"In particular, we noted that:

- *Despite specific direction to the contrary, LANL made a procedural change to its existing waste procedures that did not conform to technical guidance provided by the Department for the processing of nitrate salt waste; and*
- *Contractor officials failed to ensure that changes to waste treatment procedures were properly documented, reviewed and approved, and that they incorporated all environmental requirements for TRU waste processing. These weaknesses led to an environment that permitted the introduction of potentially incompatible materials to TRU storage drums. Although yet to be finally confirmed, this action may have led to an adverse chemical reaction within the drums resulting in serious safety implications."*

WIPP failings
The February 14 accident has shone a light on multiple problems at WIPP (discussed in greater detail in Nuclear Monitor #787).[12] A DOE-appointed Accident Investigation Board released a report into the accident in April.[13] The report identified the "root cause" of the accident to be the many failings of Nuclear Waste Partnership, the contractor that operates the WIPP site, and DOE's Carlsbad Field Office. The report criticised their "failure to fully understand, characterize, and control the radiological hazard. The cumulative effect of inadequacies in ventilation system design and operability compounded by degradation of key safety management programs and safety culture resulted in the release of radioactive material from the underground to the environment, and the delayed / ineffective recognition and response to the release."
The Accident Investigation Board report states that personnel did not adequately recognise, categorise, or classify the emergency and did not implement adequate protective actions in a timely manner. It further noted that there is a lack of a questioning attitude at WIPP; a reluctance to bring up and document issues; an acceptance and normalisation of degraded equipment and conditions; and a reluctance to report issues to management, indicating a chilled work environment.
Trento said: "The report has a familiar litany and tone: Ignored warnings from the Defense Facilities Board, lack of DOE contractor supervision, and a missing safety culture. There are hundreds of similar reports about the Savannah River Site, LANL, Oak Ridge, Hanford and other DOE national laboratories and sensitive national security sites. The Department of Energy is in serious trouble."[6]
A US Environmental Protection Agency review of air testing at WIPP in February and March found discrepancies in recorded times and dates of sample collections, flawed calculation methods, conflicting data and missing documents. It also found that WIPP managers sometimes said air samples contained no detectable levels of radiation when measurable levels were present.[14]
Compromised response to the accident
A degraded safety culture was responsible for the accident, and the same failings inevitably compromised the response to the accident. Among other problems:[4,6]

- The DOE contractor could not easily locate plutonium waste canisters because the DOE did not install an upgraded computer system to track the waste inside WIPP.

- The lack of an underground video surveillance system made it impossible to determine if a waste container had been breached until long after the accident. A worker inspection team did not enter the underground caverns until April 4 − seven weeks after the accident.
- The WIPP computerised Central Monitoring System has not been updated to reflect the current underground configuration of underground vaults with waste containers.
- 12 out of 40 phones did not work so emergency communications could not reach all parts of WIPP in the immediate aftermath of the accident.
- WIPP's ventilation and filtration system did not prevent radiation reaching the surface, due to neglect.
- The emergency response moved in slow motion. The first radiation alarm sounded at 11.14pm. Not until 9.34am did managers order workers on the surface of the site to move to a safe location.

Everything that was supposed to happen, didn't. Everything that wasn't supposed to happen, did.

References:

1. Southwest Research and Information Center, 12 Sept 2014, 'WIPP Radiation Release'.
2. Laura Zuckerman / Reuters, 30 June 2014, 'Scientists unable to recreate chemical reaction suspected in New Mexico radiation leak'.
3. Alex Jacobs, 1 Oct 2014, 'Radiation Leak Linked to Los Alamos; Do We Really Want Biological Agents There?'
4. Ralph Vartabedian, 24 Aug 2014, 'Cause of New Mexico nuclear waste accident remains a mystery'.
5. Matthew Wald, 29 Oct 2014, 'In U.S. Cleanup Efforts, Accident at Nuclear Site Points to Cost of Lapses'.
6. Joseph Trento, 5 June 2014, 'Breaking Bad: A Nuclear Waste Disaster'.
7. Department of Energy, 30 Sept 2014, 'Waste Isolation Pilot Plant Recovery Plan'.
8. Caty Enders, 30 Sept 2014, 'Congress pushes nuclear expansion despite accidents at weapons lab'.
9. Rebecca Bell, 2 Nov 2014, 'Nuclear waste must be out of sight, but not out of mind'.
10. Staci Matlock, 2 Sept 2014, 'Review, relabeling of LANL waste raises questions about scope of problem'.
11. DOE Office of Inspector General, 30 Sept 2014, 'Remediation of Selected Transuranic Waste Drums at Los Alamos National Laboratory − Potential Impact on the Shutdown of the Department's Waste Isolation Plant'.
12. 'Fire and leaks at the world's only deep geological waste repository', 6 June 2014, Nuclear Monitor #787.
13. DoE 'Radiological Release Accident Investigation Report'.
14. Laura Zuckerman / Reuters, 22 Aug 2014, 'Air Testing Lapse At New Mexico Nuclear Waste Dump Blamed On Staff Vacancy'.

4.6 What are the security implications created by the storage or disposal of intermediate or high level waste at a purpose-built facility? Could those risks be addressed? If so, by what means?

Security risks include those associated with transportation − see 4.10.

Nuclear engineers Alan Parkinson and John Large warned that the proposed NT dump would be attractive to terrorists wanting to make a 'dirty bomb', a radioactive weapon delivered by conventional means. The same risk applies to any comparable store of nuclear materials. When the Howard government was planning a repository in SA, the government envisaged that there would be no on-site security presence whatsoever. When later governments planned a repository and waste store in the NT, it was envisaged that would be a small on-site security presence (two guards at any one time). The more

dangerous waste forms (long-lived intermediate level waste, stored above ground) would be more easily accessible than less dangerous forms (low level waste buried in a repository).

One of the security risks associated with plans to import foreign spent nuclear fuel / high level nuclear waste is that waste must be secured not just for years, decades or even centuries, but millennia. Thus there is a body of literature about how future generations might be warned about radiological hazards, long after warning signs have disappeared, engineered and geological barriers have been compromised, etc.[703]

The IAEA summarises problems associated with nuclear theft, smuggling and other such illicit activities:[704]

"From January 1993 to December, 2013, a total of 2477 incidents were reported to the ITDB by participating States and some non-participating States. Of the 2477 confirmed incidents, 424 involved unauthorized possession and related criminal activities. Incidents included in this category involved illegal possession, movement or attempts to illegally trade in or use nuclear material or radioactive sources. Sixteen incidents in this category involved high enriched uranium (HEU) or plutonium. There were 664 incidents reported that involved the theft or loss of nuclear or other radioactive material and a total of 1337 cases involving other unauthorized activities, including the unauthorized disposal of radioactive materials or discovery of uncontrolled sources."

'Material Unaccounted For' at Sellafield:

The hazards associated with nuclear reprocessing were highlighted in April 2005 with the revelation of an accident at the THORP reprocessing plant at Sellafield. A broken pipe led to the leaking into a containment structure of 83,000 litres of a highly radioactive liquor containing dissolved spent nuclear fuel. The leakage went undetected for at least eight months. The accident was classified as Level 3 ('serious incident') on the 7-point International Nuclear Event Scale and British Nuclear Group Sellafield Limited was fined 500,000 pounds plus costs after pleading guilty to three serious, prolonged breaches of its licence conditions.

What is significant about the THORP leakage is not the small environmental and health risk it posed but the fact that the liquid spill contained 160 kgs of plutonium − enough to build 15-20 nuclear weapons − yet the loss went undetected for at least eight months.

The UK Health and Safety Executive concluded: "An underlying cause was the culture within the plant that condoned the ignoring of alarms, the non-compliance with some key operating instructions, and safety-related equipment which was not kept in effective working order for some time, so this became the norm. In addition, there appeared to be an absence of a questioning attitude, for example, even where the evidence from the accountancy data was indicating something untoward, the possibility of a leak did not appear to be considered as a credible explanation until the evidence of a leak was incontrovertible."[705]

Proliferation issues

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[703] See for example Scott Beauchamp, 24 Feb 2015, 'How to Send a Message 1,000 Years to the Future', www.theatlantic.com/technology/archive/2015/02/how-to-send-a-message-1000-years-to-the-future/385720/

[704] www-ns.iaea.org/security/itdb.asp

[705] UK Health and Safety Executive report: http://web.archive.org/web/20081126075501/http://www.hse.gov.uk/nuclear/thorpreport.pdf
See also www.whitehavennews.co.uk/news/Thorp-N-leak-alarms--ignored-d43b046a-acb6-4687-bc93-5c9622ca71eb-ds

Some waste forms − in particular spent fuel − might be accessed for fissile material for nuclear weapons − by national governments or sub-national groups. Moreover, should Australia accept foreign spent fuel, Australia would have sufficient weapons-useable plutonium to build many weapons. Typically, one tonne of spent fuel contains around 10 kgs of plutonium, and 10 kgs of 'reactor grade' plutonium is sufficient to build one weapon. Thus, Pangea's (abandoned) plan to transport 75,000 tonnes of spent fuel to Australia would have meant that Australia possessed 750 tonnes of plutonium − sufficient to build 75,000 nuclear weapons. Thus Australia, regardless of intent, would be far closer to a weapons capability than is currently the case and regional countries might therefore decide to take steps towards a weapons capability. A counterargument is that Australia already has a fissile material production capability due to the operation of the OPAL research reactor. However the plutonium production capability of the OPAL reactor is not known (the NFCRC could seek advice from ANSTO); certainly the plutonium production in the previous HIFAR reactor was negligible, as it was fuelled by highly enrichment uranium.

It is sometimes argued that Australia would be making a contribution to global non-proliferation efforts by accepting foreign nuclear waste. For example a Lowy Institute article states that Australia's acceptance of foreign spent fuel / nuclear waste would "reinforce non-proliferation objectives".[706] However it is not clear that non-proliferation efforts would be advanced − it would depend on many factors. As mentioned, Australia's acceptance of spent fuel would add to the number of countries with significant stockpiles of fissile material − in that sense it would contribute to proliferation risks, not to the resolution of those risks.

BHP Billiton's submission to the Switkowski Review stated:[707]
"BHP Billiton believes that there is neither a commercial ***nor a non-proliferation case*** *for it to become involved in front-end processing or for mandating the development of fuel leasing services in Australia. ... There is no evidence that a change to current Australian Government policies to facilitate domestic enrichment, fuel leasing and high level waste disposal would lead to significant economic opportunities* ***or reduce proliferation risks*** *in the foreseeable future." (emphasis added)*

4.7 What are the processes that would need to be undertaken to build confidence in the community generally, or specific communities, in the design, establishment and operation of such facilities?

Nuclear engineer Alan Parkinson has noted:[708]

"The disposal of radioactive waste in Australia is ill-considered and irresponsible. Whether it is short-lived waste from Commonwealth facilities, long-lived plutonium waste from an atomic bomb test site on Aboriginal land, or reactor waste from Lucas Heights. The government applies double standards to suit its own agenda; there is no consistency, and little evidence of logic."

A demonstrated ability to manage Australia's radioactive waste would be a necessary precursor to establishing some degree of confidence that Australia could manage foreign waste. As discussed previously (section 1.9), failed and objectionable attempts to impose repositories in SA and the NT, and the botched 'clean up' of Maralinga, provide strong grounds for public scepticism.

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[706] John Tilemann, 13 Feb 2015, 'SA's Royal Commission into nuclear energy: Let's talk about waste', www.lowyinterpreter.org/post/2015/02/13/Australias-nuclear-future-Building-on-Maralinga-and-Olympic-Dam.aspx?COLLCC=934222631&
[707] http://web.archive.org/web/20070830182528/www.pmc.gov.au/umpner/submissions/223_sub_umpner.pdf
[708] Alan Parkinson, 2002, 'Double standards with radioactive waste', *Australasian Science*, www.foe.org.au/anti-nuclear/issues/oz/britbombs/clean-up

A demonstrated ability to manage (Australia's) low- and intermediate level radioactive waste would be a necessary precursor to establishing some degree of confidence that Australia could safely manage high level nuclear waste.

Despite a promotional campaign in *The Advertiser*, including uncritical reporting of absurd claims that importing foreign waste would allow for the provision of free electricity and the abolition of all state taxes, an opinion poll in March 2015 found that just 15.7% of South Australians support a nuclear waste dump in SA, and just 26.6% support a nuclear power station in SA.[709]

Uranium mining would need to be properly regulated to establish some degree of community confidence. They would necessitate, amongst other things, repeal of all the indefensible legal privileges that the Olympic Dam mine enjoys under the Roxby Downs Indenture Act, requirements for ISL uranium miners to restore groundwater to pre-mining conditions, etc. etc.

Establishing some accountability for past failings would also help to build community confidence. To give just a couple of examples:

- the former CEO of ARPANSA could be called before the NFCRC to explain why ARPANSA described the Maralinga 'clean up' as world's best practice when it was clearly no such thing.
- BHP Billiton executives and SA government politicians and officials could be called before the NFCRC to explain the extraordinary situation whereby radiation plans for Olympic Dam were more than 15 years out of date.

To restore a degree of confidence among Aboriginal people, the following steps could be taken (among others)

- full compliance of the Olympic Dam mine with the current version of the SA Aboriginal Heritage Act, as opposed to the current (bizarre and indefensible) situation whereby Olympic Dam need only partially comply with a dated version of the Act that was never proclaimed.
- a proper 'clean up' of the Maralinga site, with suitable apologies for the botched clean up and for all the misinformation that attended the 'clean up' (e.g. claims that Traditional Owners supported deep trench burial of radioactive waste when the burial was not deep and Traditional Owners explicitly distanced themselves from the trench burial decision).
- a thorough investigation into 'divide and rule' tactics deployed against Aboriginal groups in order to advance uranium and waste repository projects, couple with legislative and other measures to prevent such tactics being deployed in future.
- a belated apology for the unilateral extinguishment of Native Title rights and interests in order to progress the plan for a national radioactive waste repository near Woomera.
- The provision of an effective veto right over uranium and other nuclear developments for Aboriginal communities in order to help address the existing deeply unfair power imbalance.

The following statements/articles are indicative of the deep distrust that currently prevails:

> ***South Australian Traditional Owners say NO!***
> *Statement from a community meeting held in Port, Augusta, on Saturday 16 May 2015 to discuss The Royal Commission Into The Nuclear Fuel Cycle*
> *We oppose plans for uranium mining, nuclear reactors and nuclear waste dumps on our land. We call on the SA Royal Commission to recommend against any uranium mining and nuclear projects on our lands.*

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[709] Paul Starick, 13 March 2015, 'Voters reject Premier Jay Weatherill's agenda to transform the state', www.adelaidenow.com.au/news/south-australia/voters-reject-premier-jay-weatherills-agenda-to-transform-the-state/story-fni6uo1m-1227262025901

We call on the Australian population to support us in our campaign to prevent dirty and dangerous nuclear projects being imposed on our lands and our lives and future generations. Endorsed by members from the following groups, present at the Port Augusta meeting: Kokatha, Kokatha-Mirning, Arabunna, Adnyamathanha, Yankunytjatjara-Pitjanjatjara, Antikirinya-Yunkunytjatjara, Kuyani, Aranda, Western Aranda, Dieri, Larrakia, Wiradjuri.

Maralinga victim of nuclear tests protests Weatherill dump bid
Verity Edwards, The Australian, 3 March 2015
www.theaustralian.com.au/national-affairs/indigenous/maralinga-victim-of-nuclear-tests-protests-weatherill-dump-bid/story-fn9hm1pm-1227245351150
A PROMINENT Aboriginal elder who was blinded by the British nuclear testing on the Maralinga Tjarutja Lands in the 1950s and 60s has called on the South Australian government not to consider storing waste in his country.
Yami Lester, who was just 10 when he became ill and lost his sight when the British tested their first bombs at the outback site, has questioned why the South Australian Labor government would consider allowing nuclear waste to be stored at Maralinga after federal governments had spent 43 years cleaning up the region, costing $104 million.
"A few years ago they cleaned up Maralinga from the waste that was left over from the bomb tests ... and now they're going to put more waste back there?" Mr Lester said. "That's not fair because it's Anangu land and they won't be able to use that land. Members from the APY, Maralinga-Tjarutja and Arabunna, Kokatha lands say we don't want nuclear waste on our land."
The Maralinga Tjarutja lands were contaminated after the British exploded seven nuclear bombs 130km east of the Oak Valley township between 1956 and 1963.
Premier Jay Weatherill last month announced that he would hold a royal commission into nuclear energy.
Yesterday, the federal government called for voluntary nominations of sites for a national nuclear waste dump to store intermediate level radioactive waste and dispose of low-level waste. An independent advisory body will assess the nominated sites against a number of criteria. Maralinga has been suggested as a potential storage site even though it was handed back to its people in November.
Mr Lester questioned why the state would consider nuclear fuel, saying contamination had been proven to last for decades. He called for greater consultation with his people.
The Premier said Mr Lester's concerns were, "matters for the commissioner".
Labor MP Eddie Hughes, whose electorate covers the Maralinga Tjarutja Lands, said he would oppose any moves to dump waste in the state's north.

4.10 What are the risks associated with transportation of nuclear or radioactive wastes for storage or disposal in South Australia? Could existing arrangements for the transportation of such wastes be applied for this purpose? What additional measures might be necessary?

Serious transport incidents

Numerous serious nuclear transport accidents and incidents have occurred. Some examples are listed in a UK government report:[710]

- 1985 − UK − Iridium-192 radiography source exposed in guide tube in van. Driver failed to monitor and drove for about one hour. Estimated worker dose: 600 mSv. (For reference, the maximum

[710] J.S. Hughes, D. Roberts, and S.J. Watson, July 2006, 'Review of Events Involving the Transport of Radioactive Materials in the UK, from 1958−2004, and their Radiological Consequences', http://webarchive.nationalarchives.gov.uk/20140714084352/www.hpa.org.uk/webc/HPAwebFile/HPAweb_C/1194947346295

permissable annual dose for nuclear industry workers is 20 mSv averaged over five years, or 50 mSv in any one year.)

- 1975 − UK − Iridium-192 radiography source fell from guide tube during use; exposed during subsequent journey. Estimated worker doses: 200 mSv, 2 x 10 mSv.
- 1975 − UK − Iridium-192 radiography source container supposed to be empty; loose lid fell of exposing two iridium sources. Estimated worker dose: 5,000 mSv (extremity) / 4 mSv (whole body).
- 1968 − UK − Iridium radiography source fell out of a container due to failure of retaining bolt. Estimated worker doses: extremities 730 mSv (extremity) / 2,380 mSv (whole body), 410 mSv (extremity) / 510 (whole body), 73 mSv (extremity) / 52 mSv (whole body).
- 1969 − UK − Detached radiography source placed in a van, exposed during journey. Estimated worker doses: 2 x 1000 mSv (extremity), 460 mSv and 510 mSv (whole body).
- 1969 − UK − Deliberate exposure to iridium source; vehicle driver exposed. Estimated worker dose 500 mSv.

Another serious nuclear transport incident occurred in the UK in 2002.[711] AEA Technology was fined £250,000 for the incident during a 130-mile truck journey. A highly radioactive beam was emitted from a protective flask as it was driven across northern England and it was "pure good fortune" that no-one was dangerously contaminated, Leeds Crown Court was told. The problem arose when a plug was left off a specially-built 2.5-tonne container carrying radioactive material on a lorry. Staff used the wrong packaging equipment and failed to carry out essential safety checks before the radioactive cobalt-60 (decommissioned cancer treatment equipment) was transported from West Yorkshire to Cumbria. The court heard the 8mm-wide beam of radiation escaped through the bottom of the flask, pointing directly into the ground, throughout the three-hour road journey. Had the beam travelled horizontally, anyone within 280 metres would have been at risk of contamination from a beam of gamma rays up to 1000 times more powerful than a "very high dose rate". Radiation experts from the Health and Safety Executive said that anyone exposed to the beam could have exceeded the legal dose within seconds and suffered burns within minutes. One scientist estimated that someone standing a metre from the source and in the direct path of the rays would have been dead in two hours. The judge, Norman Jones, QC, said staff at the firm had acted in a "cavalier and somewhat indifferent" manner with a "degree of arrogance" towards their duties. He said the risk from the leak had been "considerable". In addition to the fine, he ordered the company to pay more than £150,000 in costs to the UK Health and Safety Executive.

Costs of transport accidents

An example of a million-dollar accident occurred in Roane County, Tennessee in 2004. A Bechtel-Jacobs truck spilled strontium-90 across nearly two miles of Highway 95. More than five hours after the spill occurred, authorities finally closed the road. Highway 95 remained closed for two days, after sections of the road were cleaned and re-paved. The Department of Energy said the clean-up bill would exceed US$1 million.[712]

Nuclear transport accidents involving spent nuclear fuel / high level nuclear waste have the potential to be extraordinarily expensive. Dr. Marvin Resnikoff and Matt Lamb from Radioactive Waste Management Associates in New York City calculated 355−431 latent cancer fatalities attributable to a

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[711] UK Health and Safety Executive, 2006, 'Transport case prompts HSE reminder on the importance of radiation protection controls', www.hse.gov.uk/press/2006/e06017.htm
See also: 'Firm fined £250,000 over radioactive leak', The Scotsman, 21 February 2006, http://news.scotsman.com/topics.cfm?tid=112&id=267752006
See also: 'Toxic truck leak a radiation near-miss', 22 February 2006, www.theaustralian.news.com.au/common/story_page/0,5744,18231965%5E2703,00.html
[712] www.nuclearfiles.org/menu/timeline/timeline_page.php?year=2004

"maximum" hypothetical rail cask accident, compared to the US Department of Energy's estimate of 31 fatalities. Using the Department of Energy's model, they calculated that a severe truck cask accident could result in US$20 billion to US$36 billion in cleanup costs for an accident in an urban area, and a severe rail accident in an urban area could result in costs from US$145 billion to US$270 billion.[713]

International experience − UK

A UK government database − RAdioactive Material Transport Event Database (RAMTED) − contains information on 1018 events from 1958 to 2011 (an average of 19 incidents each year).[714] In the 20 years from 1992−2011, the average number of incidents was 26.[715] The greater number of incidents in recent years is inconsistent with industry and government rhetoric concerning steady improvements in nuclear transport safety.

UK accidents and incidents transporting radioactive materials[716]
Year / Number of reported incidents
2006 / 29
2007 / 26
2008 / 39
2009 / 33
2010 / 30
2011 / 38

Of the 38 incidents in 2011 in the UK:

- 11 involved irradiated nuclear fuel flasks (up from eight in 2010). One of those 11 events involved a low-impact collision.[717]
- Only one of the 38 incidents resulted in any potentially significant radiation dose − that incident involved the transport of a radiopharmaceutical source.[718]
- In 18 of the 38 incidents, the radioactive cargo was being moved to or from Sellafield. The Office for Nuclear Regulation (ONR) only agreed to release that information after it was challenged under freedom

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[713] 7 July 2000, www.state.nv.us/nucwaste/news2000/nn10719.htm
[714] Some recent annual reviews of transport incidents in the UK are posted at http://webarchive.nationalarchives.gov.uk/20140722091854/www.hpa.org.uk/Publications/Radiation/CRCEScientificAndTechnicalReportSeries/
Some earlier annual reviews are posted at: http://webarchive.nationalarchives.gov.uk/20140722091854/www.hpa.org.uk/Publications/Radiation/HPARPDSeriesReports/
The most recent annual review is as follows: M.P. Harvey and A.L Jones, Aug 2012, 'HPA-CRCE-037 - Radiological Consequences Resulting from Accidents and Incidents Involving the Transport of Radioactive Materials in the UK – 2011 Review', www.hpa.org.uk/Publications/Radiation/CRCEScientificAndTechnicalReportSeries/HPACRCE037/
[715] M.P. Harvey and A.L Jones, Aug 2012, 'HPA-CRCE-037 - Radiological Consequences Resulting from Accidents and Incidents Involving the Transport of Radioactive Materials in the UK – 2011 Review', www.hpa.org.uk/Publications/Radiation/CRCEScientificAndTechnicalReportSeries/HPACRCE037/
[716] M.P Harvey and A.L Jones (UK Health Protection Agency), August 2012, 'Radiological Consequences Resulting from Accidents and Incidents Involving the Transport of Radioactive Materials in the UK − 2011 Review', commissioned by UK Office for Nuclear Regulation, www.hpa.org.uk/Publications/Radiation/CRCEScientificAndTechnicalReportSeries/HPACRCE037/
[717] M.P Harvey and A.L Jones (UK Health Protection Agency), August 2012, 'Radiological Consequences Resulting from Accidents and Incidents Involving the Transport of Radioactive Materials in the UK − 2011 Review', commissioned by UK Office for Nuclear Regulation, www.hpa.org.uk/Publications/Radiation/CRCEScientificAndTechnicalReportSeries/HPACRCE037/
[718] M.P Harvey and A.L Jones (UK Health Protection Agency), August 2012, 'Radiological Consequences Resulting from Accidents and Incidents Involving the Transport of Radioactive Materials in the UK − 2011 Review', commissioned by UK Office for Nuclear Regulation, www.hpa.org.uk/Publications/Radiation/CRCEScientificAndTechnicalReportSeries/HPACRCE037/

of information law. Even after the freedom of information request, ONR refused to name the hospitals, universities and other agencies outside of the nuclear industry involved in accidents. The ONR was reluctant to release information on the grounds that revealing the organisations involved "would make them unwilling to provide information on a voluntary basis" in the future.[719] Arguably the reporting of incidents should be mandatory.

- 29 of the 38 transport accidents in 2011 were to or from nuclear industry sites (including Sellafield, Springfields nuclear fuel fabrication plant near Preston, and nuclear power stations) [720]

In their report on 806 recorded radioactive transport incidents in the UK from 1958−2004, Hughes et al. found that the modes of transport were as follows: road 32%; rail 24%; fork lift truck 22%; air 13%; sea 7%; other 2%.[721]

MATERIAL TYPE *Source: Hughes et al, 2006*[722]	**NUMBER OF EVENTS (806) FROM 1958−2004**	**PERCENTAGE**
Medical & industrial isotopes	376	46.7
Residues inc discharged INF flasks	111	13.8
Irradiated fuel	101	12.5
Radiography sources	78	9.7
Radioactive wastes	63	7.8
Uranium ore concentrate	33	4
Other	44	5.5

Of 806 incidents in the UK between 1958−2004, 2.3% (19 incidents) resulted in individual whole-body doses over 1 mSv, or extremity doses over 50 mSv; 65% resulted in no radiation doses above those expected for normal transport conditions; and presumably no information on radiation doses was available for the remainder of the incidents.[723]

There were 187 events during the shipment of irradiated nuclear fuel flasks from 1958−2004[724] − 23% of the total number of 806 recorded incidents :

- 33% involved excess contamination on the surface of the flask;
- 24% involved collisions and low speed derailments of the conveyance;
- 16% involved flask preparation faults, and loading/unloading faults;
- 13% involved excess contamination of conveyance;

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[719] Rob Edwards, 18 Dec 2012, 'Sellafield involved in 18 nuclear transport accidents', www.robedwards.com/2012/12/sellafield-involved-in-18-nuclear-transport-accidents.html

[720] Rob Edwards, 18 Dec 2012, 'Sellafield involved in 18 nuclear transport accidents', www.robedwards.com/2012/12/sellafield-involved-in-18-nuclear-transport-accidents.html

[721] J.S. Hughes, D. Roberts, and S.J. Watson, July 2006, 'Review of Events Involving the Transport of Radioactive Materials in the UK, from 1958−2004, and their Radiological Consequences', http://webarchive.nationalarchives.gov.uk/20140714084352/www.hpa.org.uk/webc/HPAwebFile/HPAweb_C/1194947346295

[722] J.S. Hughes, D. Roberts, and S.J. Watson, July 2006, 'Review of Events Involving the Transport of Radioactive Materials in the UK, from 1958−2004, and their Radiological Consequences', http://webarchive.nationalarchives.gov.uk/20140714084352/www.hpa.org.uk/webc/HPAwebFile/HPAweb_C/1194947346295

[723] J.S. Hughes, D. Roberts, and S.J. Watson, July 2006, 'Review of Events Involving the Transport of Radioactive Materials in the UK, from 1958−2004, and their Radiological Consequences', http://webarchive.nationalarchives.gov.uk/20140714084352/www.hpa.org.uk/webc/HPAwebFile/HPAweb_C/1194947346295

[724] J.S. Hughes, D. Roberts, and S.J. Watson, July 2006, 'Review of Events Involving the Transport of Radioactive Materials in the UK, from 1958−2004, and their Radiological Consequences', http://webarchive.nationalarchives.gov.uk/20140714084352/www.hpa.org.uk/webc/HPAwebFile/HPAweb_C/1194947346295

- 11% involved faults with the conveyance; and
- the remainder included three cases involving fire on a locomotive with no damage to flasks

There is no evidence of safety improvements in recent years:
- In 2008, 18% of recorded incidents (7/39) involved irradiated nuclear fuel flasks.[725]
- In 2009, 24% of recorded incidents (8/33) involved irradiated nuclear fuel flasks.[726]
- In 2010, 27% of recorded incidents (8/30) involved irradiated nuclear fuel flasks.[727]
- In 2011, 29% of recorded incidents (11/38) involved irradiated nuclear fuel flasks.[728]

The following article illustrates problems of secrecy and dishonesty:

> **The Vulcan Saga**
> Safe Energy e-Journal No.62, April 2014,
> http://no2nuclearpower.org.uk/documents/SAFE_ENERGY_No62.pdf
> On 6th March Defence Secretary Philip Hammond announced that low levels of radioactivity had been discovered in the cooling waters of the nuclear submarine test reactor – Vulcan – located next to Dounreay in Caithness. Mr Hammond told MPs that no leak had occurred and said there were no safety implications for staff working on the site, or risks to the environment. But, as a result, the Trident submarine HMS Vanguard would be refuelled with a new nuclear core at a cost of £120m. The problem was discovered in 2012. (1)
> However, despite Hammond's statement to Parliament that there was no leak, the mishap caused a tenfold increase in emissions to the atmosphere. According to the Scottish Environment Protection Agency (SEPA) discharges of radioactive 'noble' gases like argon, krypton and xenon had been boosted by the incident. Official figures show that emissions of the gases to the atmosphere rocketed from 0.19 gigabecquerels of radioactivity in 2011 to 2.16 Gbq in 2012. (2)
> Although SEPA was told about the incident in October 2012 the Agency was asked by the MoD to keep the matter secret "on a strict need-to-know basis for security reasons," so the first Scottish Ministers knew about it was when Hammond made his statement to Parliament. The Sunday Herald also reported that the Office for Nuclear Regulation (ONR) wasn't informed of the problem at Vulcan until the summer of 2012, months after it happened.
> According to Hammond, the incident resulted in the Vulcan reactor being shut down for a period in 2012. But it was of "*no safety significance*", he said, and Vulcan "*is, and remains, a very safe and low risk site.*" But former senior MoD safety official, Fred Dawson, pointed out that the MoD had not yet figured out the cause of the cooling water contamination. "*This being the case I have difficulty in believing their words of reassurance. If the leak is so insignificant and of no safety concern, why is the MoD planning early replacement of submarine reactor cores at great cost to the taxpayer?*" he asked.
> Lieutenant commander Rory Stewart, deputy commander of the Vulcan naval reactor near Dounreay in Caithness, told the Dounreay Stakeholder Group in March 2012 that "*There was*

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[725] M. P. Harvey, Aug 2010, 'HPA-CRCE-003 - Radiological Consequences Resulting from Accidents and Incidents Involving the Transport of Radioactive Materials in the UK – 2009 Review', www.hpa.org.uk/Publications/Radiation/CRCEScientificAndTechnicalReportSeries/HPACRCE003/
[726] M. P. Harvey, Aug 2010, 'HPA-CRCE-003 - Radiological Consequences Resulting from Accidents and Incidents Involving the Transport of Radioactive Materials in the UK – 2009 Review', www.hpa.org.uk/Publications/Radiation/CRCEScientificAndTechnicalReportSeries/HPACRCE003/
[727] M. P. Harvey and A. L. Jones, 2011, 'HPA-CRCE-024: Radiological Consequences Resulting from Accidents and Incidents Involving the Transport of Radioactive Materials in the UK – 2010 Review', www.hpa.org.uk/Publications/Radiation/CRCEScientificAndTechnicalReportSeries/HPACRCE024/
[728] M.P. Harvey and A.L Jones, Aug 2012, 'HPA-CRCE-037 - Radiological Consequences Resulting from Accidents and Incidents Involving the Transport of Radioactive Materials in the UK – 2011 Review', www.hpa.org.uk/Publications/Radiation/CRCEScientificAndTechnicalReportSeries/HPACRCE037/

little new to report." We now know that Vulcan was shut down for investigations between January and November 2012. (3) Members of the Stakeholder Group were said to be outraged. (4) The Scottish Environment Secretary Richard Lochhead said "*Not only did the Ministry of Defence not inform the people of Scotland, the Scottish Parliament or the Scottish Government of this nuclear-related issue, they actually told the local community there was 'little to report' when clearly there was plenty to report*." (5)

As a result of this deception Richard Lochhead has announced that the Scottish Government is to end the Ministry of Defence's historic protection from regulation and prosecution for radioactive pollution. Under current law SEPA can only regulate plants like Vulcan under a "flawed gentlemen's agreement" with the MoD. This means that SEPA has no legal authority within the Vulcan site, and no power to force the MoD to take action if there are concerns. Lochhead argued that the exemption for the MoD under the 1993 Radioactive Substances Act was an anomaly. "*There is no good reason that radioactive substances should be treated any differently from other risks to the environment*," he said. (6) The Scottish Parliament recently passed the Regulatory Reform (Scotland) Act, introducing a new environmental regulation regime. "*We want to get rid of anomalies like Crown exemption and treat all those subject to regulation even-handedly*," said Lochhead. "*We therefore propose to use the forthcoming regulations under the Regulatory Reform Act to leave behind the Crown exemption for MoD sites*."

Crown exemption used to be widespread in areas like environmental protection and health and safety, but has been reduced over the years. In Scotland, it applies to other MoD sites as well as Vulcan, including the Faslane nuclear submarine base and the Coulport nuclear weapons store on the Clyde and the Dundrennan military firing range near Kirkcudbright where depleted uranium shells have been fired. (6)

Defence Secretary Philip Hammond issued a correction in parliament to an answer concerning an incident at the Vulcan submarine reactor test site. The correction changes the line "there *has been no measurable change in the radiation discharge*" to "*no measureable change in the alpha-emitting particulate discharge*". (7)

At the end of March a group of NGOs wrote to ONR about this incident. In the letter they said: *"The Secretary of State's recent announcement suggests that the security grounds for concealing the incident were flimsy and, as a champion of openness and transparency within the nuclear sector, we would have liked to have seen ONR robustly challenge the MoD claim that discussion of the incident should be on a 'need to know' basis."*

The groups say this matter strengthens the case for the appointment of an independent representative with a mandate from NGOs to the ONR Board with a remit to scrutinise the quality of corporate decision-making and act as a champion for openness, transparency, and accountability at all levels in the organisation.

1. BBC 6th March 2014 www.bbc.co.uk/news/uk-politics-26463923
2. Sunday Herald 9th March 2014 www.robedwards.com/2014/03/salmond-accuses-defence-minister-of-deceiving-mps-on-radioactive-pollution.html
3. Rob Edwards 10th March 2014 www.robedwards.com/2014/03/vulcangate-the-anatomy-of-deceit.html
4. Press and Journal 11th March 2014 www.pressandjournal.co.uk/Article.aspx/3606636
5. Herald 11th March 2014 www.heraldscotland.com/news/home-news/snp-ramp-up-pressure-over-cover-up-at-dounreay-plant.23663408
6. Rob Edwards 11th March 2014 www.robedwards.com/2014/03/mod-immunity-on-radioactive-pollution-to-end.html
7. BBC 12th March 2014 www.bbc.co.uk/news/uk-scotland-highlands-islands-26552046

International experience − Canada

Since 2010, more than one truck in seven carrying radioactive material has been pulled off the road by Ontario ministry of transportation inspectors for failing safety or other requirements.[729] The information is contained in a notice filed with a panel studying a proposal to establish a radioactive waste repository near Kincardine. The notice states that since 2010, inspectors examined 102 trucks carrying "Class 7 Dangerous Goods (Radioactive material.)" Of those, 16 were placed "out-of-service," which means the vehicle "must be repaired or the violation corrected before it is allowed to proceed." Violations included: faulty brake lights; "load security" problems; flat tires; false log; damaged air lines; and a driver with no dangerous goods training. In other cases, trucks were allowed to proceed but were slapped with enforcement actions for problems with hours of service; annual inspection requirement; missing placards; exceed gross weight limit; speed limiter; overlength combination; overheight vehicle; vehicle registration / insurance. In total, 25 of the 102 inspections − nearly one in four − resulted in the vehicle being place out-of-service and / or enforcement action taken against the operator of the vehicle.

International experience − Germany − a nuclear 'cartel of liars'

A whistleblower supplied the WISE-Paris NGO with information which sparked a major controversy over frequent excessive radioactive contamination of waste containers, rail cars, and trucks.[730] Nuclear waste shipments from German nuclear reactor sites to reprocessing plants in the UK and France were banned, and transport within France was suspended, in the aftermath of the controversy.

WISE-Paris summarised the controversy in mid-1998:[731]

There are two scandals, both unprecedented. The first lies in the fact that for 15 years the nuclear industry - power plants, transport companies, plutonium factories and nuclear safety institutes in France, Germany, Switzerland and the UK at least - have managed to hide the fact that the international transport regulations for spent fuel shipments have been constantly violated, up to levels exceeding several thousand times the limit. This is all the more stunning as the original recommendation stems from the industry friendly, heavily pro-nuclear International Atomic Energy Agency (IAEA) in Vienna.

The second scandal derives from the fact that the French nuclear safety authority DSIN has been aware of the problem since autumn 1997, agreed with the French nuclear industry representatives over the wording of a mere "cleanliness problem", and kept silent until a journalistic investigation brought the story to light. The safety authority neither informed its ministers nor its foreign counterparts and, of course, nor did it inform the public. Worse, when the story broke, the authority played the role of the tough transparent State control agency finally cleaning up ... without actually taking any kind of regulatory or disciplinary consequences, while downplaying health consequences and the persistent outrageous violation of regulations.

The risk seems rather high that people have been exposed to significant levels of radiation over the period the contaminated transports have crossed countries. Worse, hot particles have been spread into the environment along rail tracks and roads. People might actually continue to get contaminated presently and for a long time to come.

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[729] John Spears, 15 Nov 2013, 'Trucks with radioactive cargo fail inspections',
www.thestar.com/business/2013/11/15/trucks_with_radioactive_cargo_fail_inspections.html
Ministry of Transportation − Undertaking #61: www.ceaa-acee.gc.ca/050/documents/p17520/95562E.pdf
[730] WISE-Paris, Plutonium Investigation, No.6, May-June 1998,
www.wise-paris.org/index.html?/english/ournewsletter/6_7/contents.html
and
www.wise-paris.org/english/ournewsletter/6_7/no6_7.pdf
[731] www.wise-paris.org/index.html?/english/ournewsletter/6_7/editorial.html&/english/frame/menu.html

French Environment Minister Dominique Voynet said:

Beyond the level of contamination, I'm shocked by the fact that as soon as one asks some simple questions to the operators, one realises that this has been going on for years, that the three companies questioned (EDF, Transnucléaire, COGEMA) were perfectly aware of it and that they have not said anything.

In Germany, an opinion poll found that 72% of respondents thought that further nuclear waste shipments would be "irresponsible". The opinion poll found a dramatic increase in opposition to nuclear power, with 76% of respondents supporting the idea of a law to phase out nuclear power. The police trade union speaker Konrad Freiberg called the nuclear industry a "cartel of liars" which "has driven democracy against the wall".

International experience − France

In 2008, the French nuclear safety agency IRSN produces a report summarrising radioactive transport accidents and incidents from 1999−2007. The IRSN manages a database listing reported deviations, anomalies, incidents and accidents (known in a generic way as "events") relating to transport. The database lists 901 events from 1999−2007 − on average 100 events annually or about two each week.

The IRSN report notes:[732]

- Events where there is contamination of packages and means of transport were still frequent in 2007.
- The number of events related to a defect in package stowing was significant, as was the number involving shocks on packages during handling. "Analysis of these two types of event reveals failures of information or training of the operators."
- "A number of events have been induced by human error in conditioning the radioactive contents of the packages, leading to significant consequences on the safety of the package. In particular, the incident with the highest level of gravity on the INES scale since 1999 (an incident which occurred on 27th December 2001 at Roissy airport during transit between Sweden and the United States) is linked to an error in packaging iridium capsules in the package, which led to their displacement in a portion of the cavity without radiation protection."
- "Finally, efforts should continue to prevent losses of packages and, if necessary, to find the lost packages quickly in order to avoid significant risks to uninformed persons in the event of unsupervised opening of these packages."

International experience − USA

In the eight years from 2005 to 2012, 72 incidents involving trucks carrying radioactive material on US highways caused US$2.4 million in damage and one death, according to the Transportation Department's Pipeline and Hazardous Materials Safety Administration.[733]

A 2013 incident illustrates jurisdictional and reporting issues.[734] On 22 August 2013 in Ohio, USA, involving a flaming truck carrying uranium hexafluoride. Nuclear regulators in Canada – where the

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[732] IRSN (France), 21 October 2008, 'Information report: Incidents in transport of radioactive materials for civil use: IRSN draws lessons from events reported between 1999 and 2007',
www.irsn.fr/EN/publications/technical-publications/Documents/IRSN_ni_transports_analysis_20081021.pdf
www.irsn.fr/EN/Library/Documents/IRSN_ni_transports_analysis_20081021.pdf
www.irsn.fr/EN/Pages/home.aspx

[733] Anna M. Tinsley, 15 April 2012, 'Radioactive waste may soon travel on DFW highways',
http://web.archive.org/web/20130504150446/www.star-telegram.com/2012/04/15/3884220/radioactive-waste-may-soon-travel.html

cargo originated – and in the US were not informed of the incident. Indeed there was no requirement for them to be notified. The fire was caused by brake overheating. The driver Brian Hanson doused the fire with water and thought he had extinguished it, and climbed back into the cab to call for a service truck. Then he realised the fire wasn't out and disconnected the trailer.

Hanson said: "I wound the legs down and disconnected it from the truck, losing the hair on my arms because it was really burning at that time – which I figure was kind of crazy in hindsight. But we're so programmed and told about the danger of a load, and the media danger. We're basically taught that the media's like terrorism. We're supposed to do everything we can to avoid media. I wanted to get the fire away from the uranium hexaflouride because it's heat activated ... It's really nasty stuff, and they would have had to evacuate a huge neighbourhood we were beside. ... So I got the truck disconnected, it was burning like crazy, fire blazing out the back, trying to get to a safe place to get off the highway and away from the load. I made it two miles before the truck was disabled, but I got off on the exit ramp and by that time the police were just seconds behind me, and the fire trucks were on the way."[735]

The shipment came from a Cameco refinery in Port Hope, Ontario, Canada. Cameco said: "Uranium hexafluoride is transported in special containers that are designed and tested to withstand a significant impact and at least 30 minutes engulfed in flames at a temperature of 800 degrees Celsius." The material is transported in a cylinder about 1.2 metres in diameter and 6 metres long, containing 12,000 kilograms. According to Argonne National Laboratory (ANL) – a U.S. Department of Energy research lab – if uranium hexafluoride interacts with water or water vapour, it is "chemically toxic," forming dangerous hydrogen fluoride gas. ANL states that uranium "is a heavy metal that, in addition to being radioactive, can have toxic chemical effects (primarily on the kidneys) if it enters the bloodstream by means of ingestion or inhalation," and hydrogen fluoride "is an extremely corrosive gas that can damage the lungs and cause death if inhaled at high enough concentrations."[736]

Another incident illustrates how a single error can compound. As many as 5,618 shipments of radioactive waste were made to a nuclear landfill in Washington state without the correct radioactive waste signage required on shipping containers. The containers were not marked with the required state Department of Transportation magnetic placards indicating the radioactivity of each load. The mistake dated back to a single incorrect calculation in 2011. Because the paperwork was done once for all shipments, the error carried through until it was discovered much later.[737]

Uranium transport

Some examples of uranium transport incidents are listed here.

5 January 2011: A semi-trailer loaded with uranium oxide became bogged in Kakadu National Park. None of the material, contained in 44-gallon (200-litre) drums in two shipping containers, leaked when the semi-trailer bogged on the side of the Arnhem Highway. The bogging occurred as the driver pulled over to let a truck pass about 20 kilometres from the Ranger uranium mine. Police closed a stretch of the

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[734] John Spears, 31 Oct 13, 'Burning truck hauling nuclear load flies under radar', www.thestar.com/business/2013/10/31/burning_truck_hauling_nuclear_load_flies_under_radar.html
[735] John Spears, 31 Oct 13, 'Burning truck hauling nuclear load flies under radar', www.thestar.com/business/2013/10/31/burning_truck_hauling_nuclear_load_flies_under_radar.html
[736] John Spears, 31 Oct 13, 'Burning truck hauling nuclear load flies under radar', www.thestar.com/business/2013/10/31/burning_truck_hauling_nuclear_load_flies_under_radar.html
[737] Jennifer Kalish, 6 Sept 2013, 'Radioactive waste shipments sent to landfill with incorrect signage', www.wasterecyclingnews.com/article/20130906/NEWS01/130909984/radioactive-waste-shipments-sent-to-landfill-with-incorrect-signage
See also: www.tri-cityherald.com/2013/09/04/2556830/hanford-waste-hauled-without-correct.html

Arnhem Highway for three hours until a crane arrived on the scene. The crane lifted the two containers off the bogged semi-trailer and on to another semi-trailer parked on the highway.[738]

The semi-trailer blocking the Arnhem Highway as a crane offloads the shipping containers.

In October 2014 there was an accident with the transport of uranium oxide at Outer Harbor in South Australia. A shipping container with drums of uranium oxide slipped and fell to the ground. Emergency services and the Environmental Protection Agency were called to attend. As there were no appropriate facilities at Outer Harbor, the shipping container had to be taken back to Olympic Dam to be opened and assessed. According to BHP Billiton, some uranium from a drum inside the container spilt, but there was no escape from the container.[739]

On July 3, 2009, two ships collided in Drogden Rende on the Danish side of Öresund strait just north of the Öresund bridge. The hulls of both ships sustained heavy damage. Malta-registered cargo vessel "Kapitan Lus", loaded with aluminum and 182 t of "raw" uranium, was rammed in the side by the Norwegian chemical tanker "Sundstraum", carrying methanol. The uranium transport was on the way from St Petersburg in Russia to Le Havre in France. No persons were injured and no environmental releases occured. There was sunny weather with excellent visibility in the Öresund region and none of the vessels had reported any technical problems before the crash. The crew of the "Sundstraum" declared that they had technical problems with the steering system.[740]

On July 26, 2007, a small spill of yellowcake was detected during the unloading of a container from a railcar at Comurhex's Malvési uranium conversion plant. The container held 36 barrels of natural uranium concentrate produced in Niger. It turned out that one of the uranium barrels was damaged and around 30 kgs of yellowcake had spilled inside the container. Traces of spilled uranium were also found

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[738] 'Uranium truck mishap in Kakadu', Lindsay Murdoch, 7 January 2011, www.theage.com.au/national/uranium-truck-mishap-in-kakadu-20110106-19hjl.html
'Yellowcake truck mishap blocks park access', Justin O'Brien, 6 January 2011, www.ntnews.com.au/article/2011/01/06/205311_ntnews.html
[739] Christopher Russell, 20 November 2014, 'Olympic Dam ‘significant' but productivity's key - BHP', www.adelaidenow.com.au/business/olympic-dam-significant-but-productivitys-key-bhp/story-fni6uma6-1227129286242
[740] Dagens Nyheter July 4, 2009
www.wise-uranium.org/utiss.html
Greenpeace Sweden, July 3, 2009

on the ship that had carried the container before the rail transport. The event was rated Level 1 of the International Nuclear Events (INES) scale.[741]

1986: A truck carrying 16 tonnes of uranium pellets crashed into the Snake River in western U.S. when the driver swerved to avoid a slow moving farm combine. The uranium was being shipped from Ohio to Hanford Nuclear Reservation where it is made into fuel elements that go into the Hanford nuclear reactor.[742]

October 1977, Colorado, USA: An alert was declared near Springfield after 19 tonnes of powdered uranium oxide fell from the back of a truck after an accident. The material was being transported from Wyoming to Oklahoma for processing. Colorado State Department later urged the N.R.C. to review its safety standards. Department spokesman said: "Luckily no other traffic came along. If cars had churned through the powder we could have been faced with a major crisis."[743]

December 1977, Colorado, USA: 10,000 lbs. of radioactive uranium concentrate spreads over a large area, in some places up to a foot deep, after a truck crashes. Wrong decontamination equipment sent to area. Twelve hours before health specialist on scene.[744]

17 February 2014, Kayelekera uranium mine in Malawi: Paladin reported that a truck carrying a container of uranium oxide overturned. The container fell loose and was punctured by a tree stump, and a "small quantity" uranium oxide concentrate spilled out. Paladin said both the spilled material and the soil that it came in touch with had been removed and taken back to the tailings dam at the mine.[745]

January 2011, Canada en route to China: Uranium spill on Altona ship. This incident is notable as it was recent, Cameco claimed that an unseaworthy vessel was being used for uranium transport, it illustrates the potential for expensive and protracted legal battles to follow transport accidents, etc.

Altona spill

After travelling through days of bad weather, the crew of the Altona ship notified Cameco on 3 January 2011 that several of its sea containers had shifted and a number of drums fell out leaking uranium concentrate. The ship was carrying 770,000 pounds of uranium concentrate in about 840 drums. The ship tried to stop in at Honolulu but was prevented by the US Coast Guard, which raised concerns over the hazardous nature of the material. Cameco asked the Altona to turn around while it was sailing between Hawaii and the Midway Islands and set a route back to Canada.

All of the containers were removed from the ship and taken back to the Key Lake uranium mill in Saskatchewan. All of the uranium had remained within the ship's hold according to Cameco. Each container was inspected on removal from the hold then wrapped in an overpack before trucking to Key Lake. The clean up required specialised knowledge and equipment, neither of which were available aboard the Altona or at its port of destination. In March, the last of the spilled yellowcake sent back to Saskatchewan, and crews finished cleaning the ship about a month later.

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[741] ASN, Aug 9, 2007
www.wise-uranium.org/epfr.html#COMCONVMA
[742] Washington Post 14/10/86; WISE News Communique #262, 31/11/86
[743] West Australian, 7 October 1977
[744] Nation Review, 3 May 1979
[745] 17 Feb 2014, 'Product Shipment Incident near Kayelekera Mine, Malawi',
http://ir.paladinenergy.com.au/Investor-Centre/?page=News---Announcements
Peter Ker, 17 Feb 2014, 'Paladin Energy spills radioactive material at African mine', www.theage.com.au/business/mining-and-resources/paladin-energy-spills-radioactive-material-at-african-mine-20140217-32v7v.html

Cameco Corporation sued the ship owner, a company called MS MCP Altona GMBH, for C$19 million dollars for losses suffered as a result of the accident. Cameco alleged that the ship's owners were negligent in the way they handled the cargo, saying the vessel was unseaworthy, that the containers weren't secured properly and that the ship was steered into seas that were too rough to navigate safely.

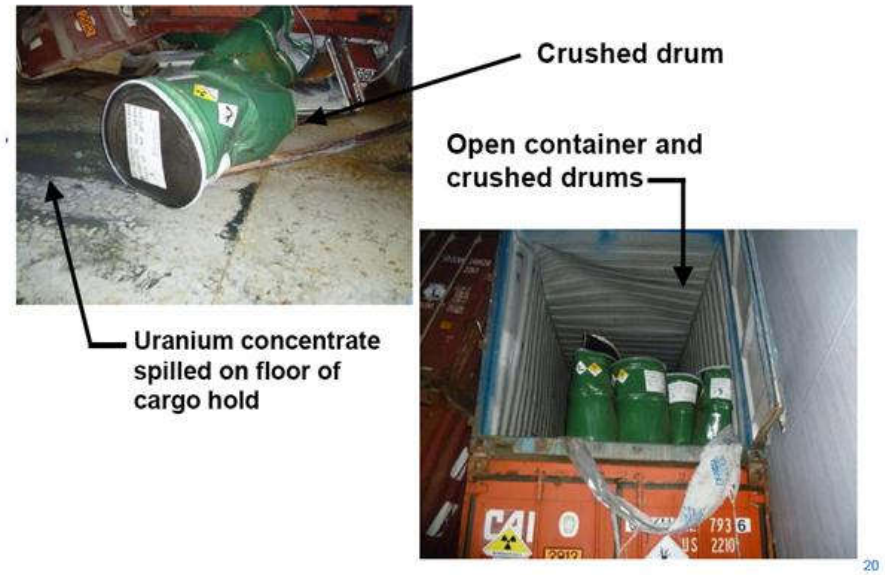
MS MCP Altona GMBH went bankrupt, meaning Cameco had to wait for the ship to be sold before it had any chance of securing any funds if successful in the legal action. Cameco went after other companies involved in the transport, including Germany-based Hartmann Schiffahrts GMBH and Co. and Hartmann Shipping Asia as well as others.

In a statement of defence, the Hartmann companies put the blame back on Cameco, alleging that the drums weren't properly secured inside the containers, that the containers weren't properly selected, that Cameco hadn't hired competent stevedores, and hadn't provided adequate instructions to them, and that it didn't remediate the vessel in a cost-effective way.

The Altona was sold in late 2011 while legal actions were set to continue for some considerable time.

Sources:

- www.calgaryherald.com/technology/Cameco+uranium+spill/4134597/story.html
- Canadian uranium return completed, 25 March 2011, www.world-nuclear-news.org/newsarticle.aspx?id=29708
- MCP Altona, Wikipedia, http://en.wikipedia.org/wiki/MCP_Altona
- Ship Carrying Radioactive Material Docked in Vancouver for over 2 months after Uranium Spill, 8 Aug 2011, http://enformable.com/2011/08/ship-carrying-radioactive-material-docked-in-vancouver-for-2-months-after-uranium-spill/
- Uranium spill ship moored in limbo off North Vancouver, James Weldon, 25 September 2011, www.vancouversun.com/story_print.html?id=5456058&sponsor=
- Radioactive spill ship in legal limbo off North Vancouver, James Weldon, 26 September 2011, www.vancouversun.com/technology/Radioactive+spill+ship+legal+limbo+North+Vancouver/5461526/story.html
- North Vancouver bids adieu to uranium ship, James Weldon, 22 November 2011, www.vancouversun.com/North+Vancouver+bids+adieu+uranium+ship/5749809/story.html



Above: damaged uranium concentrate barrels on the Altona.

Waste transport

A few examples of accidents and incidents involving the transport of radioactive waste are noted here.

September 2002: A truck carrying nuclear waste from Idaho to the Waste Isolation Pilot Plant in New Mexico, USA, ran off Interstate 80 in Wyoming. The driver said he felt ill and attempted to pull over, but he blacked out before he made it to the roadside. The truck crossed the median, headed across the westbound lane and left the road. The accident was the second in less than two weeks. On Aug. 25, a truck bound for the WIPP plant near Carlsbad was hit by an alleged drunk driver. Nobody was injured and no contaminants were released in either accident, WIPP officials said.[746]

23 December 2013: A rail freight wagon carrying nuclear waste was derailed at a depot in Drancy, 3 km northeast of Paris. The wagon carried spent fuel from the Nogent nuclear power plant destined for AREVA's reprocessing plant at La Hague in Normandy. Although no leakage of radiation was measured at the accident location, the Nuclear Safety Authority (ASN) reported that subsequent testing by AREVA revealed a hotspot on the rail car that delivered a dose of 56 microsievert. An investigation into the origin of the contamination is underway.[747]

1976, Kentucky, USA: Six drums containing radioactive waste burst open after they rolled off tractor-trailer trucks in Ashfield, Kentucky, USA. Two drivers were slightly injured. When the highway was cleaned, checks indicated radioactivity.[748]

3 February 1997 − High-level nuclear waste transport derails. A train carrying three casks with about 180 tons of high-level radioactive waste derailed near Apach (France). The waste was on its way from the nuclear power plant in Lingen (Germany) to Sellafield, UK, where it is to be reprocessed. The train was going at about 30 kilometers per hour, and the casks did not turn over. The incident was not a unique event. On 15 January 1997 a nuclear fuel cask derailed in front of the German nuclear power plant at Krümmel during a track change, and on 3 February 1997 the engine driver of a nuclear waste transport from Krümmel suffered from a faint.[749]

16 January 2014: A driver abandoned his stricken car at a level crossing moments before it was dragged 300 metres down a railway track by an empty nuclear waste train. The train is used to take spent nuclear fuel to Sellafield but, as it was returning to Cheshire, was empty.[750]

Sea transport

In May 2013, fire damaged the Atlantic Cartier ship carrying nine tons of uranium hexafluoride while it was in the Port of Hamburg. (According to some reports the ship was also carrying 11.6 tons of uranium oxide.) The uranium hexafluoride was destined for the Areva-owned uranium enrichment plant at

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[746] AP, 9 Sept 2002, 'WIPP truck runs off highway in Wyoming', http://lubbockonline.com/stories/090902/upd_075-3941.shtml

[747] International Panel on Fissile Materials, 21 Jan 2014, http://fissilematerials.org/blog/2014/01/nuclear_train_accident_in.html

[748] Legislative Research Service Paper, Parliamentary Library, Canberra

[749] WISE News Communique #467, February 28, 1997
Die Tageszeitung (FRG) February 5, 1997
Greenpeace press release February 4, 1997

[750] CORE Briefing, 15 Jan 2014, www.corecumbria.co.uk/newsapp/pressreleases/pressmain.asp?StrNewsID=331
www.lancasterguardian.co.uk/news/nuclear-waste-train-in-50mph-smash-1-6376671
Morning Star, 16 Jan 2014, www.morningstaronline.co.uk/a-e91c-Level-crossing-crash-exposes-dangers-of-nuclear-trains
Lancaster Guardian, 16 Jan 2014, www.lancasterguardian.co.uk/news/nuclear-waste-train-in-50mph-smash-1-6376671

Lingen, Lower Saxony. Authorities said containers with dangerous substances were promptly removed from the ship. Firefighters took 16 hours to douse the fire, with a shortage of extinguishing agent in the region hampering their efforts. Five fire-fighting boats and 296 fire-fighters were involved. Only 500 metres from the burning ship, around 35,000 people were involved in a civic event − they were not warned about the potential hazards and they were not directed to move away.[751]

The Atlantic Cartier in Hamburg.

July 2002: UK destroyer HMS Nottingham ran aground on the submerged but well-charted Wolf Rock near Lord Howe Island. A 50 metre hole is torn down the side of the vessel from bow to bridge, flooding five of her compartments and nearly causing her to sink.[752]

A 2001 report, 'A Review of Aspects of the Marine Transport of Radioactive Materials', by visiting UK-based marine pollution expert Tim Deere-Jones, revealed confusion about which Australian State or Commonwealth agency would take responsibility for an at-sea nuclear accident. It found that up to eight different agencies could be involved in an emergency that would probably involve State emergency personnel who lack nuclear emergency equipment or training. The report found that the Pacific Nuclear Transport Ltd (PNTL) ships, Pacific Pintail and Pacific Teal, which travelled close to the Australian coast via the Tasman Sea, and the Bougeunais, which carried nuclear waste from Sydney, did not meet the highest safety standards.[753]

Edwin Lyman, (then) Scientific Director at the Nuclear Control Institute, wrote in a 1999 paper:[754]

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[751] Martyn Lowe, 25 Aug 2013, 'Next Destination − Antwerp', www.theproject.me.uk/?p=492
Maritime Bulletin, 17 May 2013, www.news.odin.tc/index.php?page=view/article/416/Fire-on-ro-ro-Atlantic-Cartier-could-spark-explosions-and-radioactive-contamination-Hamburg
The Local, 17 May 2013, www.thelocal.de/national/20130517-49777.html
May 2013, http://rt.com/news/hamburg-radioactive-ship-fire-464/
Fairplay, 22 May 2013, www.fairplay.co.uk/login.aspx?reason=denied_empty&script_name=/secure/display.aspx&path_info=/secure/display.aspx&articlename=dn0020130522000014

[752] www.mapw.org.au/files/2009-06-29_fact-sheet_Nukeships-BW.pdf
https://en.wikipedia.org/wiki/HMS_Nottingham_%28D91%29

[753] Greenpeace, 15 March 2001, 'Australia not prepared for a nuclear accident at sea'

[754] Edwin Lyman, October 1999, 'The Sea Shipment of Radioactive Materials: Safety and Environmental Concerns', www.nci.org/e/el-malaysia.htm

"Recently, the IAEA has demonstrated an alarming lack of interest in the enforcement of its own regulations. For example, the IAEA standards for external contamination of shipping casks were found last year to have been routinely violated all over Western Europe for a decade or longer, by factors of up to ten thousand. One of the contributing factors was a design flaw that made adequate decontamination of some shipping casks very difficult. However, instead of reviewing the standards that permitted these casks to be licensed, it took no action. This merely reinforced the attitude which led to the problem in the first place − a pervasive belief on the part of shippers that IAEA standards were unnecessarily stringent and could be ignored. The public has no way of knowing how many other aspects of the existing regulations are treated in such a cavalier fashion. ...
The shipping packages now used to transport large quantities of radioactive material (RAM) by sea are designed to meet a set of performance requirements known as "Type B" standards, which are defined in the IAEA's transport standards, the most recent of which are the "Regulations for the Safe Transport of Radioactive Material" (1996 edition). Most notably, the standards require that Type B packages withstand a series of drop tests from a height of 9 meters, followed by an 800 degrees C fire for thirty minutes, without significant breach of the containment. For packages containing large inventories of RAM, an immersion test in water at 200 meters' depth for one hour is required.
These standards were originally developed for land-based modes of transport, and questions have arisen regarding their adequacy for packages used for sea shipments, which may be subject to more severe accident conditions, including more energetic collisions, long-duration, high-temperature fires and long-term immersion or immersion at greater depths. The IAEA's response to this issue has been two-fold. First, it argues that although accident conditions that occur aboard ships may be more severe than the Type B testing regimen, the actual accident environment experienced by a RAM package most likely would be less severe. Second, it claims that Type B packages have substantial safety margins built into them, so that even if they experience more severe conditions than they were designed to withstand they will "fail gracefully" rather than abruptly.
There is scant evidence, however, for either of these assumptions. ...
Recent evidence indicates that the long-term public health consequences of a severe accident during the sea transport of highly radioactive materials could be comparable to those resulting from a loss-of-containment accident at a nuclear reactor. On the other hand, the shippers of RAM and regulatory authorities are unable to provide convincing arguments that the risk of such an accident is negligible. Therefore, the safety case for these shipments has not been made."

Atlantic Osprey

Pangea-successor ARIUS proposed dedicated ships being used to transport nuclear waste to Australia, meeting the strictest standards. In reality, there is a history of sub-standard ships being used to transport nuclear materials. For example, the Atlantic Osprey, owned by the UK Nuclear Decommissioning Authority, was used to transport nuclear materials until it was retied in late 2013.755

It was an old converted car ferry, lacking the safety and security attributes of other nuclear cargo carriers. A 2010 assessment by NDA-subsidiary International Nuclear Services of the Atlantic Osprey conceded the reduced ‘public acceptance and political credibility' of transporting Category 1 nuclear material on the ship, and admitted that reservations about the Atlantic Osprey's continued use for Category 1 cargoes had been expressed by France's safety authority.[756]

[755] www.world-nuclear-news.org/WR-Final-voyage-for-Atlantic-Osprey-2208147.html
[756] November 2012, 'Yet more ‘intolerable risk’ as Sellafield MOX fuel awaits shipment to Germany', www.corecumbria.co.uk/newsapp/pressreleases/pressmain.asp?StrNewsID=310

In 2002, an engine fire broke out on the Atlantic Osprey while it was crossing the Manchester Ship Canal, although there was no nuclear material on board at the time.[757] The ship experienced engine failures, fires and cases of drifting at sea.[758]

UK report

The Atlantic Osprey has been taken out of service but questions remain about the adequacy of ships still being used for nuclear transports.

The UK Nuclear Free Local Authorities noted in 2014:[759]

In the example of the Atlantic Cartier, it was transporting significant amounts of uranium hexaflouride ... but also other dangerous chemicals, explosive materials and cars for export. Last year it was involved in a major fire, where a significant radioactive emergency incident was only narrowly involved in Hamburg Port, Germany. Less than four months later the vessel was back in operation, delivering and unloading at UK ports such as Liverpool. This is despite a long list of safety concerns[760] on the vessel that had been identified over the past few years.

Launching a detailed Policy Briefing written by independent marine pollution consultant Tim Deere-Jones, the Nuclear Free Local Authorities' recommendations included:[761]

- ships carrying dangerous cargoes into any port should be issued with a public notice about the potential dangers which they might cause;
- any ship carrying radioactive materials should have regular fire inspections;
- any ship which fails to pass such tests should be prevented from sailing;
- the ship owners and the ship management should be held legally responsible for any breach of these regulations;
- any ship carrying radioactive materials should be subject to a new set of rigorous fire and safety standards regulations;
- international shipping regulations are changed so that no radioactive materials can be transported on any ships which carry either explosives, or highly inflammable liquid gases.

Tim Deere-Jones said:[762]

"It is evident from my ongoing research that the safety of the majority of maritime transports of radioactive materials through European waters cannot be guaranteed. The regulations covering such transports are generally little better than those covering "non-radioactive" cargos. The UK National Marine Pollution Plan, in common with many other National Plans, contains no specific plan for response to maritime radiological incidents. European Port and Local Authorities, Emergency Responders and Government Agencies appear similarly poorly prepared for reaction to such events. In

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[757] Treacy Hogan, 28 March 2002, 'Protests after fire on Sellafield nuclear waste ship', www.unison.ie
[758] Safe Energy E-Journal, No.57, December 2012, www.no2nuclearpower.org.uk/documents/SAFE_ENERGY_No57.pdf
[759] Nuclear Free Local Authorities, 4 March 2014, 'NFLA publishes marine nuclear materials transportation briefing which raises concerns over emergency procedures for lower level mixed material vessel shipments', www.nuclearpolicy.info/docs/news/NFLA_nuclear_marine_transport_briefing.pdf
[760] NFLA media release, 28 August 2013, www.nuclearpolicy.info/docs/news/NFLA_Atlantic_Cartier_concerns.pdf
[761] Nuclear Free Local Authorities, 4 March 2014, 'NFLA publishes marine nuclear materials transportation briefing which raises concerns over emergency procedures for lower level mixed material vessel shipments', www.nuclearpolicy.info/docs/news/NFLA_nuclear_marine_transport_briefing.pdf
[762] Nuclear Free Local Authorities, 4 March 2014, 'NFLA publishes marine nuclear materials transportation briefing which raises concerns over emergency procedures for lower level mixed material vessel shipments', www.nuclearpolicy.info/docs/news/NFLA_nuclear_marine_transport_briefing.pdf

order to forestall a serious maritime radiological accident, I fully support the NFLA call for improvements to the management of such shipments and for both Nation States and the International Maritime Organisation to tighten the current lax international regulations."

Parida ship fire

In October 2014, a ship carrying radioactive waste which was set adrift in the North Sea after it caught fire caused the evacuation of the nearby Beatrice oil platform, part-owned by Ithaca Energy. The MV Parida was transporting six 500-litre drums of cemented radioactive waste from Scrabster in northern Scotland to Antwerp, Belgium, when the fire broke out in one of its funnels. The blaze was put out by the ship's crew. Meanwhile 52 workers were airlifted off the oil platform as a precaution in case the drifting MV Parida struck it. The ship was subsequently towed to a secure pier at the Port of Cromarty Firth by a commercial operator, despite the Aberdeen coastguard sending two emergency tugs to assist. The cargo was reportedly undamaged. The waste was from the Dounreay experimental nuclear power plant.[763]

Angus Campbell, the leader of the Western Isles Council, said the Parida incident highlighted the need for a second coastguard tug in the Minch. "A ship in similar circumstances on the west coast would be reliant on the Northern Isles-based ETV [emergency towing vessel] which would take a considerable amount of time to get to an incident in these waters."[764]

Nuclear transport security

Hirsch et al. summarise some of the security risks associated with the transport of nuclear materials:[765]

> *During transport, radioactive substances are a potential target for terrorists. Of the numerous materials being shipped, the following are the most important:*
> *1. Spent fuel elements from nuclear power plants and highly active wastes from reprocessing (high specific inventory of radioactive substances)*
> *2. Plutonium from reprocessing (high radiotoxicity, particularly if released as aerosol)*
> *3. Uranium hexafluoride – uranium has to be converted into this chemical form in order to undergo enrichment (high chemical toxicity of released substances, resulting in immediate health effects in case of release).*
> *Since the amounts transported with one shipment are about several tonnes at most, the releases to be expected will be smaller by orders of magnitudes than those that result from attack of a storage facility – even if the transport containers are severely damaged. On the other hand, the place where the release occurs cannot be foreseen, as attacks can occur, in principle,*

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[763] Andrew Snelling, 9 Oct 2014, 'Oil rig evacuated after radioactive fire', www.energynewspremium.net/StoryView.asp?storyID=826936500&section=General+News&sectionsource=s63&aspdsc=yes
NFLA / KIMO, 8 Oct 2014, 'NFLA and KIMO call for urgent inquiry into Parida nuclear waste transport fire off the Moray Firth', www.nuclearpolicy.info/docs/news/NFLA_KIMO_Parida_incident.pdf
West Highland Free Press 26 July 2014, www.whfp.com/2014/07/25/concern-over-nuclear-waste-shipments/
16 Oct 2014, 'Call for safety review following ship fire', www.fia.uk.com/en/information/details/index.cfm/call-for-safety-review-following-ship-fire
World Nuclear News, 8 Oct 2014, www.world-nuclear-news.org/WR-Dounreay-ready-to-assist-fire-investigation-08101401.html

[764] Herald, 30 July 2014 www.heraldscotland.com/news/home-news/plans-for-radioactive-waste-by-sea-are-criticised.24898732

[765] Helmut Hirsch, Oda Becker, Mycle Schneider and Antony Froggatt, April 2005, 'Nuclear Reactor Hazards: Ongoing Dangers of Operating Nuclear Technology in the 21st Century', report prepared for Greenpeace International, www.greenpeace.org/international/press/reports/nuclearreactorhazards

everywhere along the transport routes. Those routes often go through urban areas; for example at ports or during rail transport. Thus, releases can take place in densely populated regions, leading to severe damage to many people, even if the area affected is comparatively small.

Examples of nuclear transport security incidents

In 1998, Greenpeace protesters easily boarded a ship carrying highly radioactive waste. A Panama Canal Commission (PCC) memo, obtained through a Freedom of Information Act request, found that "communication, command and control ... was dysfunctional" when the Greenpeace protesters boarded the ship as it entered the Panama Canal. The PCC report noted that patrol boats had failed to spot the Greenpeace launch and that the ship's crew had thought the demonstrators to be security personnel boarding the ship. Greenpeace and the Nuclear Control Institute noted: "Had the ship been boarded by a group of well-armed attackers instead of peaceful demonstrators, its cargo would have been in grave jeopardy, with potentially catastrophic consequences for the people of Panama. Given the shippers' frequently professed concerns about security, we were astonished to discover how thoroughly inept and ineffective were the security arrangements at the Panama Canal. In fact, essential elements of the security system did not work."[766]

Tom Bielefeld discusses an incident in Mexico in 2014:[767]

At 1:30 a.m. on December 2, gunmen forced two truck drivers who had taken a nap at a gas station on the outskirts of Mexico City to surrender their vehicle. The thieves took off with the truck's heavy and hazardous cargo: a decommissioned teletherapy unit that was once used for cancer treatment and still contained a small capsule of highly radioactive material. The capsule's contents − some 3,000 curies of cobalt-60 − made it a "category 1" radiation source, the most dangerous of five categories defined by the IAEA to rank radioactive materials according to the risk they pose to people working with them. Taken out of their shielding containers, category-1 sources can kill anyone who is exposed to them at close range for a few minutes to an hour.

Two days later, the police found the radioactive capsule abandoned in a corn field. Although someone had extracted the capsule from its shielding (and likely received an unhealthy radiation dose in the process), there were no immediate reports of serious injuries and no contamination found in the area nearby. Thus the consequences of this incident appeared to be less grave than in two earlier cases − in Brazil in 1987, and in Thailand in 2000 − when unsuspecting scavengers who dismantled old radiotherapy machines exposed themselves and their families to very high doses of radiation. Four of the exposed people died in Brazil, and three in Thailand, and more were seriously injured. The cost of cleanup and recovery for their communities was substantial.

Officials, especially in the United States, were relieved that the stolen Mexican capsule did not end up with terrorists, who could have used it to build a "dirty bomb." Even though many planning scenarios predict that such a bomb would probably cause few radiation-related deaths, its economic impact could be disastrous.

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[766] 22 Dec 1998, 'Major Security Breach at Panama Canal revealed as the next nuclear waste shipment looms', www.nci.org/pr/pr122298.htm
Panama Canal Commission's Director of Safety, Environment and Security, 1998, 'Pacific Swan Greenpeace Incident', www.nci.org/seatrans.htm

[767] Tom Bielefeld, 23 Jan 2014, 'Mexico's stolen radiation source: It could happen here', http://thebulletin.org/mexico%E2%80%99s-stolen-radiation-source-it-could-happen-here

Perhaps the most worrisome lesson of the Mexican incident and the other ones above is this: If hapless truck-jackers can steal high-activity sources by accident, a well-organized terrorist group could certainly do so in a planned operation.

Transport of uranium ore from the Bagjata mine to the Uranium Corporation of India Limited (UCIL) processing plant was suspended after an ore-laden truck was torched by Maoists on 7 May 2014.[768] Fifteen armed people pulled the driver down from the vehicle and then set it ablaze. The Maoists had reportedly been demanding permanent jobs for locals as compensation for acquisition of their land in Bagjata. About 150 families were displaced to make way for the Bagjata mine and had not been compensated. "If such violent activities continue to recur time and again, we apprehend it wouldn't be easy for us to function here," a senior UCIL official said.

July 2006 − Scotland − reporter plants fake bomb on train carrying nuclear waste: An investigation was underway after a newspaper reporter planted a fake bomb on a train carrying nuclear waste. The journalist from the *Daily Mirror* claimed he had wandered up to the unattended wagons at a north-west London depot. The reporter said his only ID as a rail worker was a fluorescent orange jacket and hard hat, on sale at any builders' merchants. "This was not a one-off. It was the tenth time I had wandered freely into the depot," he said. The rail company had already been criticised for "serious lapses" − the government's Office for Civil Nuclear Safety outlined serious failings in supervision at the sidings in 2005.[769]

March 2009 − An overseas company had made several shipments of nuclear fuel feedstock to another country, calling into a UK port en route. The company forged a UK approval document, and further investigation revealed that two other shipments had taken place with suspect UK approvals.[770]

13 April 1981 − Brisbane, Australia: A panel van carrying infectious and radioactive waste and a quantity of the pesticide 245T was stolen in Brisbane. Police said it contained one drum of radioactive waste, six drums of infectious waste and a quantity of 245T.[771]

On 17 October 2001, then ANSTO CEO Helen Garnett said that claims "that security is wanting at the Lucas Heights Science and Technology Centre ... is far from the truth."[772] Exactly two months later, several dozen Greenpeace protesters clambered over the spent fuel storage building and the reactor, while a paraglider enjoyed the scenery from ANSTO's 'secure' airspace.

In Canada, the Nuclear Safety Commission listed 17 cases from 2005 to 2013 in which radioactive materials were stolen from vehicles, or in which the vehicle itself was stolen with a radiation source in the trunk. Five of these cases involved radiography cameras, all of which were eventually recovered.[773]

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[768] www.dnaindia.com/india/report-maoists-set-truck-carrying-uranium-for-ucil-ablaze-1986317
http://timesofindia.indiatimes.com/city/ranchi/Suspension-of-ore-transportation-hits-uranium-work-at-UCIL/articleshow/34961281.cms
http://timesofindia.indiatimes.com/city/ranchi/Frequent-threats-from-rebels-worry-UCIL-officials/articleshow/29483709.cms

[769] Tom Parry, 22 July 2006, 'N-TRAIN FIRM RAPPED BEFORE OVER SECURITY EXCLUSIVE', www.mirror.co.uk/news/tm_objectid=17428696%26method=full%26siteid=94762%26headline=n%2dtrain%2dfirm%2drapped%2dbefore%2dover%2dsecurity-name_page.html
'Probe after reporter plants fake bomb on nuclear train', The Scotsman, 21 July 2006, http://news.scotsman.com/uk.cfm?id=1061462006

[770] M. Harvey and A. Jones, 2011, 'Radiological Consequences Resulting from Accidents and Incidents Involving the Transport of Radioactive Materials in the UK – 2010 Review', HPA-CRCE-024, www.hpa.org.uk/Publications/Radiation/CRCEScientificAndTechnicalReportSeries/HPACRCE024/

[771] Courier Mail 14/4/81

[772] Australian Financial Review, letter.

[773] Tom Bielefeld, 23 Jan 2014, 'Mexico's stolen radiation source: It could happen here', http://thebulletin.org/mexico%E2%80%99s-stolen-radiation-source-it-could-happen-here

About 330 kilograms of weapons-grade uranium in the form of naval fuel was stolen from a US plant in the 1960s. Multiple cases of naval HEU thefts were also reported in Russia in the early 1990s.[774]

According to Mark Gaffney, author of *Dimona: the Third Temple* (1989), Israel smuggled nuclear technology (triggers, known as krytrons) out of the US, and highjacked a ship on the high seas loaded with uranium ore.[775]

Nuclear transport security: Organised crime

In September 2009, Italian authorities discovered a ship that was sunk by the mafia off the coast of southern Italy with 120 barrels of radioactive waste on board, a local prosecutor said. The 110-metre long ship, the Cunsky, was found 500 metres under water and around 28 kms from the coast of Calabria. The Cunsky is one of 32 vessels carrying toxic material that has been sunk by the mafia in the Mediterranean, according to the prosecutor's office in Reggio Calabria. The location of the Cunsky was revealed by a Calabrese mafia turncoat, Francesco Fonti, who confessed to being behind the explosion that brought the ship down. He said the mafia organisation 'Ndrangheta received £100,000 for the job. Fonti accuses 'Ndrangheta of sinking at least 30 ships loaded with toxic waste, much of it radioactive.

Environmental group Legambiente said there were between 40 and 100 suspect cases between 1985 and 1995 of ships laden with nuclear and toxic waste that mysteriously sunk in the Mediterranean's deepest points. In each of the cases, the ships never launched a May-day signal and the crew mysteriously disappeared.

A 1995 parliamentary waste commission report spoke of the "possible existence of national and international trafficking in radioactive waste, managed by business and criminal lobbies, which are believed to operate also with the approval of institutional subjects belonging to countries and governments of the European Union and outside the EU." Its conclusions noted "interferences and threats" against investigators, and were critical of ENEA, Italy's state energy research agency, and their management of nuclear waste. Former employees of ENEA are suspected of paying criminals to take waste off their hands in the 1980s and 1990s. Shipments to Somalia continued into the 1990s, while the 'Ndrangheta clan also blew up shiploads of waste, including radioactive hospital waste, and sending them to the sea bed off the Calabrian coast.

'Ndrangheta has allegedly been involved in radioactive waste dumping since the 1980s. Ships with toxic and radioactive waste were sunk off the Italian coast. In addition, vessels were allegedly sent to Somalia and other developing countries such as Kenya and Zaire with toxic waste, including radioactive waste cargoes, which were either sunk with the ship or buried on land. Legambiente alleges that local rebel groups were given weapons in exchange for receiving the waste ships.

A source with the United Nations Development Programme (UNDP) described the search for hazardous material in Somalia as "like looking for a needle in a haystack. It's not that they don't know it's there ... but that they don't know where to start looking for it."

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[774] Sébastien Philippe, 4 Sept 2014, 'Bringing law to the sea: safeguarding the naval nuclear fuel cycle', http://thebulletin.org/bringing-law-sea-safeguarding-naval-nuclear-fuel-cycle7418
See also:
Victor Gilinsky and Roger J. Mattson, 17 April 2014, 'Did Israel steal bomb-grade uranium from the United States?', http://thebulletin.org/did-israel-steal-bomb-grade-uranium-united-states7056

[775] Mark H. Gaffney, 'Obama Plays Hardball with Israel?', www.informationclearinghouse.info/article40994.htm

The sunken Cunsky

Sources and more information:

- 'Mafia sank boat with radioactive waste: official', AFP, 14 September 2009, www.google.com/hostednews/afp/article/ALeqM5iixa-TpxXyBQj--lkobYu9Bhjuaw
- 'Underwater Dump Italians Search for Radioactive Waste Sunk by Mafia', 22 October 2009, www.spiegel.de/international/europe/underwater-dump-italians-search-for-radioactive-waste-sunk-by-mafia-a-656681.html
- 'Mafia turncoat says "nuclear dump" funds deposited in Malta', September 2009, www.timesofmalta.com/articles/view/20090916/local/mafia-turncoat-says-funds-deposited-in-malta
- 'Toxic waste dumping by the 'Ndrangheta', Wikipedia, http://en.wikipedia.org/wiki/Toxic_waste_dumping_by_the_%27Ndrangheta
- 'Italian police close in on 'toxic' shipwreck', The Financial Times, 21 October 2009, www.ft.com/cms/s/0/aab01ac6-bda3-11de-9f6a-00144feab49a.html#axzz1DgKhhsM6
- 'From cocaine to plutonium: mafia clan accused of trafficking nuclear waste', The Guardian, 9 October 2007, www.guardian.co.uk/world/2007/oct/09/italy.nuclearpower
- Somalia used as toxic dumping ground, The Ecologist, March, 2009, www.theecologist.org/News/news_analysis/268581/somalia_used_as_toxic_dumping_ground.html

Nuclear transport security: US reports

A March 2014 report by the James Martin Center for Nonproliferation Studies found that in 2013, there were 153 cases where authorities in 30 countries lost control of some of their radiological and nuclear materials.[776] Most cases (141) involved materials that are radioactive but not usable in nuclear weapons. In about half of cases, the report blamed the loss of the materials on "negligence" by the people handling them. In 29% of the cases, the materials were lost or stolen during transit. The report states:

> *Nearly one-third of all documented incidents in 2013 (29 percent) involved material in transit. Of the 30 reported thefts of material, 57 percent involved transportation, while 15 percent of the 73 losses did.*
> *Incidents that occurred in transport are further classified as either "movement," in which the device was in a moving vehicle (28 incidents); or "stationary" (14 incidents), in which the vehicle was not in motion at the time of the incident. Notably, all stationary incidents were thefts.*

[776] Nuclear Threat Initiative / James Martin Center for Nonproliferation Studies, March 2014, 'CNS Global Incidents and Trafficking Database: 2013 Annual Report', www.nti.org/media/pdfs/global_trafficking_report.pdf?_=1395275964

The most publicized incident in 2013 was a theft during movement. On December 2, 2013, gunmen near Mexico City forced the drivers of a truck transporting a decommissioned cancer therapy machine to abandon their vehicle. The machine contained an encapsulated Category 1 cobalt-60 source (reportedly about 3,000 curies), thus posing serious safety and security concerns. Mexican authorities appealed to the public for help locating the truck and its contents, while also alerting the thieves to the dangerous nature of the radioactive material sealed inside the device. Two days later, police recovered the material in a cornfield, with the truck nearby.
Since thefts of materials in transit are of particular policy interest, the database further classifies thefts into additional subcategories, possibly illuminating areas of security vulnerability. First, thefts during transit are sub-classified as "stolen from vehicle" (11 incidents); "stolen with vehicle" (2 incidents); "stolen from individual" (2 incidents); or "unknown" (2 incidents).
An example of a "stolen from vehicle" incident was reported on February 4, 2013, in Phoenix, Arizona, where an individual broke into a locked steel box bolted to the bed of a truck parked outside a private home and stole a density gauge. There is no proof that the individual was aware of what he was stealing; many such crimes appear to be thefts of opportunity.
One "stolen with vehicle" incident occurred on November 18, 2013, when an individual stole a truck carrying a density gauge while the truck was parked outside of a home. As in most cases classified as "stolen with vehicle," it appears that the individual targeted the vehicle without being aware of its contents.
In one "stolen from individual" incident, an individual was riding a passenger train and carrying a portable industrial X-ray device. At one point, the individual noticed the device was missing and reported it stolen.
Thefts during transit are also sub-classified according to whether the material stolen was attended or unattended when the theft occurred. The material was attended at the time of the theft in only three of the 17 thefts during transit. In the remaining 14 incidents, the material had been left unattended when the theft occurred. ...
Policy Implication 5: Focusing on Security for Materials in Transit
Increased policy emphasis should be given to how to improve security for radioactive materials in transit. National regulatory policies differ. In some cases, new regulatory requirements or guidelines may be useful.
However, simple improvements to end-user training and awareness could also significantly decrease the number of incidents occurring in transit.
In most countries, once a device containing radioactive material is licensed for use, there appears to be little regulation governing its transportation and storage (this is particularly true of IAEA Category 3, 4, and 5 sources). In the United States, while radioactive sources must be locked into vehicles while in transit, regulations do not prohibit leaving sources in an unattended vehicle. Incident data for 2013, which includes multiple thefts from parked vehicles, suggests the possible need for additional regulation of radioactive materials while in transit, such as requiring that materials not be left unattended for lengthy periods in areas where there is general public access.
Many of the incidents that occurred during transport reflect simple negligence, and could easily have been avoided (e.g., incidents in which a licensee forgot to secure a source, and the source fell off the truck while in transit). Such incidents reinforce Key Finding 4, concerning the need to improve nuclear security training for personnel working with radioactive materials.

Harvard University 's Tom Bielefeld, a physicist specialising in nuclear security and nonproliferation research, wrote in *The Bulletin of the Atomic Scientists* in 2014 about nuclear transport security issues in the USA:[777]

[777] Tom Bielefeld, 23 Jan 2014, 'Mexico's stolen radiation source: It could happen here', http://thebulletin.org/mexico%E2%80%99s-stolen-radiation-source-it-could-happen-here

For transport security, the active involvement of all stakeholders is of particular importance. On the road, there are fewer technical protection measures available than inside buildings, so security depends even more on the people in charge: the drivers. They must be vigilant and prepared. This is primarily the responsibility of their bosses, who, in turn, must be able to rely on adequate rules and specific guidance from the regulator. Businesses must also be able to count on responsive state agencies and law enforcement. The federal government can set financial incentives to invest in better security. It is also in a unique position to provide the other parties with the information necessary to better understand the nature of the threats they might be facing. Here are some specific recommendations for the various parties involved in transport security:

- *The NRC must further strengthen its regulations. Given the scale of damage that a "dirty bomb" could cause, it's difficult to understand why there are still no armed escorts required for category-1 transports. A real-time location-tracking system should be mandatory, not just for vehicles transporting category-1 sources, but also for those with category-2 sources. Similarly, the requirement for drivers to identify "safe havens" for rest stops, before their trip begins, should be extended to category-2 transports.*
- *The states could do a lot more, too. Those that do not yet require armed escorts for category-1 transports should implement such a policy soon − and not wait for the NRC to change its rules. And if there is one lesson from the Mexican incident for the states, it's that all of them should be proactive when it comes to helping licensees identify secure parking areas.*
- *The companies themselves play the main role in protecting radioactive sources. They need to be aware that someone might be after their cargo. Drivers, in particular, must be trained to follow security protocols, avoid risky situations, and respond appropriately should they come under attack. Managers should equip their trucks with low-cost security systems—such as GPS tracking systems, duress buttons, or vehicle disabling devices—even when they are not legally required to do so.*

Improving transport security remains an urgent matter for all parties involved, but the NRC and the states must pave the way – and quickly. In addition to the measures outlined above, a new program should be initiated in which experts from government and industry work together to develop better security concepts for sources in transit.

Nuclear transport security: March 2014 Nuclear Security Summit

Only five states − Japan, France, South Korea, the UK and the USA − endorsed a statement on nuclear transport security risks. Committments include adopting the recommendations of the yet-to-be published IAEA 'Implementing Guide on the Security of Nuclear Material in Transport', and "consider[ing] mutually exchanging information on physical protection and the security of other radioactive materials ... in order to capture good practices and lessons learned." Harvard University's Matthew Bunn said the transportation gift basket "is as weak as dishwater," and he took exception to its suggestion that "the security record of civilian transport of nuclear materials has been excellent" historically. "It used to be legal to send plutonium by regular mail," Bunn noted, "and the industry complained loudly when the [U.S. Nuclear Regulatory Commission] started requiring any armed guards at all."[778]

[778] Douglas P. Guarino, 26 March 2014, 'Nations Pledge to Follow Security Guidelines for 'Dirty Bomb' Material', www.nti.org/gsn/article/nations-pledge-follow-security-guidelines-dirty-bomb-material/
Joint Statement: www.nss2014.com/sites/default/files/documents/joint_statement_on_transport_security_final.pdf
www.whitehouse.gov/the-press-office/2014/03/25/fact-sheet-enhancing-security-maritime-supply-chain-gift-basket

Radioactive materials transport in Australia − further comments

Some examples of transport accidents involving radioactive materials in Australia are noted here.

In early 1998, it was revealed that "airtight" spent fuel storage canisters had been infiltrated by water − 90 litres in one case − and corrosion had resultedt. When canisters were retrieved for closer inspection, three accidents took place (2/3/98, 13/8/98, 1/2/99), all of them involving the dropping of canisters containing spent fuel while trying to transport them from the 'dry storage' site to another part of the Lucas Heights site. The public may never have learnt about those accidents if not for the fact that an ANSTO whistleblower told the local press. One of those accidents (1/2/99) subjected four ANSTO staff members to small radiation doses (up to 0.5 mSv).[779]

19 March 1998 − Cootamundra, NSW: A semi-trailer overturned on the Olympic Way spilling its cargo of radioactive isotopes.[780]

1984 − A driver transported radioisotopes through Sydney in an improperly sealed container. The driver was exposed to the maximum permissible annual radiation dose.[781]

Apparently transporting radioactive materials on the back of a ute meets federal and NT standards:

> *Uranium miner defends moving radio-active goods in back of ute*
> *By Xavier La Canna, 20 Feb 2014*
> *www.abc.net.au/local/stories/2014/02/20/3948778.htm*
> *Uranium Miner Energy Resources of Australia Ltd (ERA) says moving radioactive material in barrels in the back of a ute is in accordance with national guidelines, after a photograph emerged showing that was happening in the Northern Territory. The photograph showed a ute carrying two green barrels bearing warnings that they contain radio-active material, apparently being moved with only a rope over the top of them on the Arnhem Highway. ERA said while the practice was in accordance with guidelines the company was reviewing what had occurred on this occasion.*
> *"ERA's normal practice is to have them contained in sealed drums and placed in an enclosed box," the company said in a statement.*
> *It said the material in the barrels was "geological samples" and did not have any processed uranium ore.*
> *"These samples were secured and transported in accordance with national and state safe transport guidelines," ERA said. ...*
> *The contractor working for ERA that was moving the material - EnLog Pacific Holdings - said NT Worksafe had confirmed the transport of the goods were in full compliance with all legislative requirements.*

Energy Resources Australia said the ute driver had a checklist to complete in case of an accident.[782]

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[779] Sutherland Shire Environment Centre:
http://nuclearhistory.wordpress.com/2011/03/17/safety-problems-at-antso/
www.ssec.org.au/our_environment/issues_campaigns/nuclear/info_sheets/2002_sep_1.htm
[780] AAP 19 March 1998
[781] Sutherland Shire Environment Centre:
http://nuclearhistory.wordpress.com/2011/03/17/safety-problems-at-antso/
www.ssec.org.au/our_environment/issues_campaigns/nuclear/info_sheets/2002_sep_1.htm
[782] www.mirarr.net/documents/2014-02-20-ntn-ute-gotta-be-kidding.pdf
http://readnow.isentia.com/ReadNow.aspx?1ZVIXwyNxeP

26 May 2010 − Bolte Bridge, Melbourne: A radioactive substance used in nuclear medicine was ejected from a vehicle during a collision between a van and a car at about 12.20pm. The accident forced the closure of the bridge for several hours causing major traffic delays. Firefighters, working with officials from the Department of Health, secured the situation, cleaned up the radioactive material, emptied the vehicle's damaged LPG tank and ensured the road was safe to reopen.[783]

5 September 2011: An accident took place involving two trucks at the intersection of the Brand and Great Northern highways at Muchea in WA. One truck was carrying radioactive isotopes used in industrial operations though there was no leakage. Police said a drum of the radioactive material rolled off the back of the truck.[784]

May 2015: Two Western Australian men were reported for transporting lithium batteries and radioactive materials in the same load, and were set to face court.[785]

ANSTO has acknowledged that there are 1−2 accidents or 'incidents' every year involving the transportation of radioactive materials to and from the Lucas Heights reactor plant.[786]

During the 2011 public comment period for Toro's proposed uranium mine at Wiluna in WA, an accident took place involving two trucks at the intersection of the Brand and Great Northern highways in WA.[787] One truck was carrying a radioactive isotope used in industrial operations though there was no leakage.

4 December 1980, Port Macquarie, NSW − truck accident

An accident near Port Macquarie involved a truck carrying a 60-litre drum labelled 'danger radioactive - Americium 241', a smaller container labeled 'Caesium 137', as well as DDT and other material. When police called the Australian Atomic Energy Commission at Lucas Heights for advice, they were told to call back later 'when the AEC opens'.

Police officers Bob Deards and Terry Clifton attended the accident. Deards said: "One of the drums was ruptured. You can see in one of the photos some kind of material leaking out and changing the colour of paint on the drum."

That afternoon the police officers began vomiting violently and suffered severe headaches. It was the first of many symptoms that would stay with them for several years. Deards suffered severe weight loss, constant headaches and fainting spells. Clifton was forced to take powerful tranquillisers and both had mental breakdowns. "I nearly pulled the trigger on myself once," Clifton said.

Clifton said: "I had two boys and a girl at the time but I never had children again ... I just wasn't game." Likewise, Deards said: "The whole bloody thing was terrible. The specialist told me to have a vasectomy and never have another child."

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[783] www.theage.com.au/victoria/bolte-bridge-delays-radioactive-spill-slows-peakhour-traffic-20100526-wcr3.html www.mfb.vic.gov.au/News/Crash-closes-Bolte-Bridge.html

[784] 'Police investigate radioactive threat from crash', 6 Sept 2011, www.abc.net.au/news/2011-09-06/radioactive-truck/2873294

[785] www.adelaidenow.com.au/news/south-australia/two-western-australian-truckies-to-face-court-for-carrying-radioactive-material-and-lithium-batteries/story-fni6uo1m-1227360571973

[786] ANSTO, 2003, Submission to NSW Parliament's 'Joint Select Committee into the Transportation and Storage of Nuclear Waste'

787 − Police investigate radioactive threat from crash, 6 September 2011, www.abc.net.au/news/2011-09-06/radioactive-truck/2873294

Despite their conditions and attempts to seek specialist treatment or advice outside the police medical officer, Deards and Clifton said they were abandoned by the police, "threatened" if they went to the media and ultimately forced out of their job − Deards after four years and Clifton after six. "Nobody wanted to do anything, they didn't give a shit, it was all in the too-hard basket," Deards said.

Dr. John McKay of Port Macquarie claimed that 16 people who attended the accident suffered from symptoms of radioactive poisoning. Dr. McKay accused the Australian Atomic Energy Commission (now ANSTO) of a cover-up.

Bob Deards and Terry Clifton in 1980. Photo: The Daily Telegraph[788]

On 3 April 2012, five road workers were sent for medical treatment after displaying symptoms of nausea, sore throat, dry mouth and vomiting when toxic material was unearthed during work on an upgrade to the Pacific Highway in New South Wales. There was speculation that they had uncovered radioactive material from the 1980 accident. A NSW government report later said there was no evidence that radioactive material was buried at the site.

Articles about the Port Macquarie accident:

- 'Buried fury at betrayal bubbles to the surface', Richard Noone, The Daily Telegraph, 20 April 2012, www.dailytelegraph.com.au/news/sydney-nsw/buried-fury-at-betrayal-bubbles-to-the-surface/story-e6freuzi-1226333766448
- 'Our nuclear fears demand inquiry', The Daily Telegraph, Editorial, 19 April 2012, www.dailytelegraph.com.au/news/opinion/our-nuclear-fears-demand-inquiry/story-e6frezz0-1226331999769
- 'Workers sick amid highway radiation scare', 18 April 2012, www.abc.net.au/news/2012-04-18/radioactive-discovery-halts-pacific-hwy-upgrade/3957168
- 'Soil, not radiation, made workers ill', 20 April 2012, www.smh.com.au/environment/soil-not-radiation-made-workers-ill-20120419-1xa31.html
- 'CFMEU-WorkCover talks over toxic Highway site', 20 April 2012, www.abc.net.au/news/2012-04-20/cfmeu-workcover-talks-over-toxic-highway-site/3962016/?site=midnorthcoast&section=news
- Lethal, toxic truth buried in a ditch, why radioactive materials, a banned pesticide and food were on the same truck that crashed on the Pacific Highway in 1980 is a mystery, www.dailytelegraph.com.au/news/sydney-nsw/lethal-toxic-truth-buried-in-a-ditch/story-e6freuzi-1226332071028

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[788] www.dailytelegraph.com.au/news/sydney-news/buried-fury-at-betrayal-bubbles-to-the-surface/story-e6freuzi-1226333766448

- 'Nuclear waste fears on Pacific Highway', 18 April 2012, www.abc.net.au/lateline/content/2012/s3480662.htm
- 'Workers sick amid highway radiation scare', 18 April 2012, www.abc.net.au/news/2012-04-18/radioactive-discovery-halts-pacific-hwy-upgrade/3957168
- 'Nuclear experts to assist NSW agencies: Pacific Highway', 18 April 2012, www.ansto.gov.au/discovering_ansto/media_centre/ansto_media_releases_2013/ansto_media_releases_2013/nuclear_experts_to_assist_nsw_agencies_pacific_highway
- 'No radiological contamination on the NSW Pacific Highway', ARPANSA, 18 April 2012, www.arpansa.gov.au/News/MediaReleases/mr1_180412.cfm
- 'Records indicate nuclear agency not involved: Pacific Highway', www.ansto.gov.au/discovering_ansto/media_centre/ansto_media_releases_2013/ansto_media_releases_2013/records_indicate_nuclear_agency_not_involved_pacific_highway
- Road workers ill after finding suspected radioactive waste, April 18, 2012, www.smh.com.au/environment/road-workers-ill-after-finding-suspected-radioactive-waste-20120418-1x6jp.html

Transportation of spent fuel / high level nuclear waste by train from a port to a storage/disposal site is proposed by Pangea-successor and others. Thus it is notable that have been numerous train derailments in Australia over the past decade. Some examples are noted here:

- 12 December 2006 − Northern Territory − another derailment on the Adelaide to Darwin railway. Two locomotives and 11 carriages of the Ghan were derailed 130 kms south of Darwin when the train and a road-train collided. A 50-year-old female passenger was in a critical but stable condition while three others were being treated for less serious injuries. Great Southern Railways said it could take five days to clear the railway.[789]
- A serious derailment occurred on 27 December 2011, when a Darwin bound train carrying copper concentrate (with trace uranium, 0.008%) from the Prominent Hill mine derailed into the Edith River northwest of Katherine. Floodwaters from a recent cyclone caused the river crossing to flood and wash out. It was estimated that 1200 tonnes of copper concentrate spilled into the Edith River when 13 carriages overturned into the river. More carriages derailed but did not overturn, and debris from carriages was recovered up to 5km down stream. The company exporting the copper, OZ Minerals, had been operating under an exemption to the Australian Code for the Transport of Dangerous Goods, granted by SafeWorkSA and NT WorkSafe. Instead of being transported in sealed containers, the copper was simply in metal tubs with tarpaulin covering.[790]
- 2012, June 7 − Northern Territory − train derailment. A Pacific National freight train carrying 6000 tonnes of manganese derailed in the NT blocking the railway and stranding 240 Ghan passengers in Alice Springs as the track was blocked. Some reports had the derailment near Alice Springs, others 60 kms north of Tennant Creek and others much closer to Muckaty land which is being targeted for a national radioactive waste facility. Muckaty traditional owner, Penelope Phillips from the Wirntiku group, said the train derailment raises concerns about the safety of transporting radioactive material.

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[789] 'Crash sparks calls for Adelaide to Darwin rail line probe', http://theaustralian.com.au/national-affairs/crash-sparks-calls-for-adelaide-to-darwin-rail-line-probe/story-fn59niix-1226390639315
'Nuke warning in Ghan crash', 13 December 2006, www.news.com.au/couriermail/story/0,23739,20925432-5010960,00.html
'Investigations begin into Ghan derailment', 13 December 2006, http://abc.net.au/news/australia/nt/alice/200612/s1810195.htm

[790] http://news.smh.com.au/breaking-newsnational/nt-rail-line-remains-cut-after-floods-20111228-1pcfh.html
AAP, April 18, 2012 – 'Pacific Highway site 'clear' of radioactive waste, Roads Minister Duncan Gay says'
'Radioactive transport accident New South Wales 1980', antinuclear.net/2012/04/18/radioactive-transport-accident-new-south-wales-1980/
ATSB, 2012 - Australian Transport Safety Bureau, "Derailment of freight train 7AD1 at Edith River near Katherine, NT", atsb.gov.au/publications/investigation_reports/2011/rair/ro-2011-019.aspx

"I think it's an omen to people, to let them know to stop trying to talk about that Muckaty waste coming to the country, whether its by rail or train," she says. Cat Beaton from the Environment Centre NT raised concerns about plans to use the train line to transport 1.2 millions tonnes of copper/uranium concentrate annually from the Olympic Dam mine in SA to the Port of Darwin.[791]

- On 25 November 2012, 14 carriages of a freight train bound for Adelaide were overturned near Cadney Park in South Australia, and other carriages derailed. Strong winds were the cause of the accident which caused "significant damage" to containers and carriages, and damaged 300m of track.

2003/04 NSW Parliamentary Inquiry into radioactive waste

In its 2004 report, NSW Parliament's 'Joint Select Committee into the Transportation and Storage of Nuclear Waste' emphasised the point that there needed to be a net benefit associated with radioactive materials transportation.[792] In the case of the planned radioactive repository in SA, no attempt to demonstrate a net benefit had even been made. The NSW Joint Select Committee noted:[793]

> *There is no doubt that the transportation of radioactive waste increases the risk of accident or incident (including some form of terrorist intervention). By continuing the storage of waste at Lucas Heights on an interim basis, there is no need to transport most of the waste and any risks associated with that transport are avoided. ...*
>
> *The Australian community benefits from the products produced by ANSTO's reactor. But it is hard to see how this justifies imposing the facilities on unwilling communities chosen virtually at random. Furthermore, it is arguable that alternative technologies and strategies can produce these radioisotopes.*
>
> *Proponents of the proposals claimed that radioactive waste was not as dangerous as other hazards, such as petrol. The committee rejects these arguments. The community accepts these goods and associated risk because of a justifiable, demonstrable benefit. Generally this is not the case with radioactive waste.*
>
> *Another consequence of a road accident was the implication for local economies such as the effects on tourism (the Blue Mountains is a World Heritage Area) and on "clean and green" agricultural products. Even if there was no spill or release in an accident, the concern the general public has regarding nuclear matters could have adverse economic impacts. No matter how low the risk, these transport proposals represent an unnecessary risk.*

The Recommendations of the Joint Select Committee are listed here as a number of them remain relevant today:

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[791] NT News, www.ntnews.com.au/article/2012/06/08/306471_ntnews.html
Train derailment fuels Muckaty fears, 8 June 2012, www.abc.net.au/local/stories/2012/06/08/3521295.htm
Freight train derails in NT, 8 June 2012, http://news.ninemsn.com.au/national/8480633/freight-train-derails-in-nt
http://news.ninemsn.com.au/national/8480633/freight-train-derails-in-nt

[792] NSW Parliament, 'Joint Select Committee into the Transportation and Storage of Nuclear Waste', Report No. 53/01 – February 2004:
www.parliament.nsw.gov.au/nuclearwaste
www.parliament.nsw.gov.au/prod/PARLMENT/Committee.nsf/0/3B435D05DCA2A3ACCA256E3D00178F7C

[793] NSW Parliament, 'Joint Select Committee into the Transportation and Storage of Nuclear Waste', Report No. 53/01 – February 2004:
www.parliament.nsw.gov.au/nuclearwaste
www.parliament.nsw.gov.au/prod/PARLMENT/Committee.nsf/0/3B435D05DCA2A3ACCA256E3D00178F7C

RECOMMENDATION 1: *The current Federal Government proposals for the Repository and the Store cannot be justified and should be abandoned. (p100)*
RECOMMENDATION 2: *The current transport proposals to the Repository (and the Store) should, therefore, also be abandoned. (p100)*
RECOMMENDATION 3: *In the interim, Lucas Heights should continue to act as a waste facility, subject to a public inquiry into the storage facilities on site to identify operating conditions which will ensure world's best practice. (p100)*
RECOMMENDATION 4: *Consequently, during the interim period of storage at Lucas Heights (p100-1): a. a new site selection process based on contemporary overseas models should be undertaken as a priority, incorporating community acceptance criteria. b. a public inquiry should be instigated by the Federal Government to consider the viability and practicality of alternative technologies and sources for radioisotope provision in Australia. Issues for consideration would include:*
i. whether or not medical and industrial isotopes can be produced from alternative sources and whether this can be achieved before the current facility has expired;
ii. the economic and industry impact of importing medical isotopes; and
iii. whether or not it is necessary for research funding to be allocated to the development of alternative sources for radiopharmaceutical production. c. the operating licence for the Replacement Research Reactor (RRR) should be deferred. An inquiry should be undertaken by the Federal Government into the need for and possible uses of the RRR. Issues for consideration would include:
i. a review of the licensing processes and conditions applied to the reactor;
ii. security issues relating to the reactor site;
iii. the impact on jobs and Australian nuclear research of not proceeding with the replacement reactor;
iv. whether an effective solution to the problem of the final management of nuclear waste has been identified;
v. emergency management and response implications of the new facility; and vi. whether there has been adequate consultation with the community, local government and the NSW Government.
RECOMMENDATION 5: *The Federal Government should accept liability for radioactive waste and indemnify state and local government, and the public against the impacts of any radioactive waste incidents. (p141)*
RECOMMENDATION 6: *The NSW Department of Environment and Conservation should complete the inventory of non-ANSTO storage sites as a matter of urgency identifying, in particular, those sites where upgrading of facilities is required. (p101)*
RECOMMENDATION 7: *The NSW Department of Environment and Conservation should liaise with the Sydney Water Corporation to ensure a proper risk assessment be carried out at the Cronulla Sewerage Outfall. In addition to emission levels in the ocean, reporting should cover environmental, human health and biophysical impacts, similar to that carried out at other Sydney Water facilities. (p78)*
RECOMMENDATION 8: *The Minister for Utilities should direct the Sydney Water Corporation to provide a copy of the ANSTO Trade Waste Agreement to Sutherland Shire Council. (p77)*
RECOMMENDATION 9: *ANSTO should acknowledge that spent fuel is waste, and in dealing with the Australian public, should identify it as waste. (p34)*
RECOMMENDATION 10: *ARPANSA should supplement the current Australian (NHMRC Code) waste classifications, Categories A, B, and C, with an equivalent range of effective dose rates (sieverts/hr) for each classification. (p111)*
RECOMMENDATION 11: *ARPANSA should develop a quantitative definition for Category S waste (NHMRC Code), to include effective dose rates thus doing away with the current 'definition by exclusion'. (p111)*

RECOMMENDATION 12: *ARPANSA should liaise with ANSTO and DEC to identify and properly secure any intermediate level waste considered suitable for use in 'dirty bombs'. (p132)*
RECOMMENDATION 13: *The New South Wales Government should formally forward a copy of this report to ARPANSA. (p141)*
RECOMMENDATION 14: *That the federal government identify any proposed road transport routes through Sydney. (p105)*
RECOMMENDATION 15: *ARPANSA should set waste acceptance criteria for any near-surface burial repository to exclude all long-lived intermediate level waste. (p70)*
RECOMMENDATION 16: *ARPANSA should require ANSTO to provide effective dose rate (sievert/hour) information for all waste containers. The dose rate will be provided for waste before conditioning as well as being measured on the outside of the container. (p111)*
RECOMMENDATION 17: *Risk assessments should be carried by New South Wales Agencies (including Police, NSW Fire Brigades, NSW Health, and the Department of Environment and Conservation), in consultation with the Commonwealth for any transport proposals. This assessment should include consideration of the risk of potential terrorist activities. (p140)*
RECOMMENDATION 18: *NSW Agencies including Police, NSW Fire Brigades, NSW Health, and the Department of Environment and Conservation should, in consultation with the Commonwealth, detail and cost the emergency services requirements to best manage any transport proposals. (p140)*
RECOMMENDATION 19: *A formal agreement should be negotiated between the NSW Government and the Federal Government on any proposals to store and transport radioactive waste in New South Wales, based on the above risk assessments. This agreement would include:*
** The Commonwealth to arrange an assessment of the transport proposals by the IAEA's Transport Safety Appraisal Service;*
** This assessment should consider all possible modes of transport, including sea, depending on the site location being assessed;*
** Clearly defined roles and responsibilities (clarify jurisdictional uncertainties);*
** Tracking of waste material;*
** Emergency services requirements (resourcing, training, responses);*
** Risk minimisation;*
** Prevention of accidents;*
** No liquid wastes to be transported;*
** Community acceptance criteria; and*
** Independent monitoring by NSW to certify or ensure that the relevant codes are adhered to (pp140,1).*
RECOMMENDATION 20: *Any agreement be based on the principle that the Federal Government bear the full costs incurred by the community (including local councils) of any transport and storage proposals. (p141)*
RECOMMENDATION 21: *The NSW State Government should obtain legal advise on the Federal Government's constitutional power relating to nuclear technology. (p45)*
RECOMMENDATION 22: *In the event the Federal Government fails to adopt the committee's recommendations 1 to 4: The NSW Government should amend the Uranium Mining and Nuclear Waste Facilities (Prohibition) Act to prohibit:*
** the construction and operation of nuclear waste facilities in New South Wales (with the exception of an interim waste facility at Lucas Heights), and*
** the transportation of reactor sourced radioactive waste (with the exception of stocks of existing spent fuel). (p101)*

Recommendation 47: The Royal Commission should recommend the establishment of an independent commission to investigate safety, security and regulatory aspects of radioactive materials transport in Australia.

4.12 Would the establishment and operation of such facilities give rise to impacts on other sectors of the economy? How should they be estimated and what information should be used? Have such impacts been demonstrated in other economies similar to Australia?

See section 1.13