Submission to NSW Standing Committee on State Development

Inquiry into the Uranium Mining and Nuclear Facilities (Prohibitions) Repeal Bill 2019

Friends of the Earth Australia
Australian Conservation Foundation
Nature Conservation Council of NSW

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1. EXECUTIVE SUMMARY

Friends of the Earth Australia, the Australian Conservation Foundation and the Nature Conservation Council of NSW welcome the opportunity to provide a submission to this inquiry. Representatives of our organisations would welcome the opportunity to appear before a public hearing of the inquiry.

There appears to be consensus that, in the words of Dr. Ziggy Switkowski at the 29 August 2019 hearing of the current federal nuclear inquiry, "the window is now closed for gigawatt-scale nuclear" in Australia. Dr. Switkowski further noted that "nuclear power has got more expensive, rather than less expensive", that "there's no coherent business case to finance an Australian nuclear industry", and that no-one knows how a network of small modular reactors (SMRs) might work in Australia because no such network exists "anywhere in the world at the moment".

The 2006 Switkowski report estimated the cost of electricity from new reactors at A$40–65 per megawatt-hour (MWh). That is one-quarter of current nuclear cost estimates such as those provided in the November 2018 Lazard's report (A$166–280/MWh or $US112–189).

In 2009, Dr. Switkowski said that the construction cost of a 1,000-megawatt (MW) power reactor in Australia would be A$4–6 billion. Again, that is one-quarter of the current cost estimates for all reactors under construction in western Europe and the US (A$17.8–24 billion).

Even without factoring in those four-fold cost increases – blowouts amounting to A$10 billion or more per reactor – Prime Minister Scott Morrison cited the findings of the 2006 Switkowski report when providing a sceptical response to a question about the economic viability of nuclear power for Australia.

As a result of catastrophic cost overruns with recent reactor projects, numerous nuclear lobbyists acknowledge that the industry is in crisis and engage each other in debates about what if anything can be salvaged from the "ashes of today's dying industry". One consequence of the industry crisis is that it sharply limits finance options and explains the growing clamour for ever-larger, multi-billion-dollar public subsidies (such as the estimated A$55–91 billion lifetime subsidies for the Hinkley Point twin-reactor project in the UK).

The industry crisis also limits the number of potential vendors of reactor technology – companies such as Westinghouse and Toshiba are no longer willing to take on the huge financial risks. The Australian Nuclear Association suggests (and promotes) South Korea as a potential supplier of reactor technology to Australia. However, as discussed in our joint submission to the current federal nuclear inquiry (submission #219, Appendix 1), the South Korean nuclear industry suffers from sustained allegations of endemic corruption and safety lapses; South Korea is itself phasing out nuclear power; it has little operational experience with its APR1400 reactor design; and its only reactor export project (in the UAE) is behind schedule and over-budget.

'Advanced' or 'Generation IV' nuclear power concepts

With respect to 'advanced' or 'Generation IV' nuclear power concepts, the findings of the 2015/16 South Australian Nuclear Fuel Cycle Royal Commission still hold. Numerous lobbyists and enthusiasts made the case for the introduction of 'advanced' nuclear reactors to South Australia but the Royal Commission concluded:

"[A]dvanced fast reactors or reactors with other innovative designs are unlikely to be feasible or viable in South Australia in the foreseeable future. No licensed and commercially proven design is currently operating. Development to that point would require substantial capital investment. Moreover, the electricity generated has not been demonstrated to be cost-competitive with current light water reactor designs."

Claims that Generation IV concepts and small modular reactors (SMRs) are leading to 'cleaner, safer and more efficient energy production' have no evidentiary basis. Given that no Generation IV reactors have commenced operation in recent years while numerous Generation IV and SMR projects have been abandoned, the only way such assertions could be justified would be with reference to concepts that exist only as designs on paper.

The words of Admiral Hyman Rickover, a pioneer of the US nuclear program, are as relevant now as when they were penned in 1953:
"An academic reactor or reactor plant almost always has the following basic characteristics: (1) It is simple. (2) It is small. (3) It is cheap (4) It is light. (5) It can be built very quickly. (6) It is very flexible in purpose ('omnibus reactor'). (7) Very little development is required. It will use mostly off-the-shelf components. (8) The reactor is in the study phase. It is not being built now.
"On the other hand, a practical reactor plant can be distinguished by the following characteristics: (1) It is being built now. (2) It is behind schedule. (3) It is requiring an immense amount of development on apparently trivial items. Corrosion, in particular, is a problem. (4) It is very expensive. (5) It takes a long time to build because of the engineering development problems. (6) It is large. (7) It is heavy. (8) It is complicated. …
"For a large part those involved with the academic reactors have more inclination and time to present their ideas in reports and orally to those who will listen. Since they are innocently unaware of the real but hidden difficulties of their plans, they speak with great facility and confidence. Those involved with practical reactors, humbled by their experience, speak less and worry more."

Examples of Generation IV and SMR projects that have been abandoned, sharply curtailed or postponed in recent years include the following:

- The French government has abandoned the planned 100–200 MW ASTRID demonstration fast reactor due to waning interest in fast reactor technology (and Generation IV concepts more generally) as well as funding constraints (which, in turn, are partly due to five-fold cost overruns with a 100 MW materials testing reactor and the extraordinary cost overruns with large Generation III EPR reactors under construction in France and Finland).
- The Russian government has postponed plans for a 1200 MW fast neutron reactor (currently there are only five such reactors worldwide, all of them smaller reactors classified as experimental or demonstration reactors by the World Nuclear Association).
- Babcock & Wilcox abandoned its mPower SMR project in the US despite receiving government funding of US$111 million.
- Transatomic Power gave up on its molten salt reactor R&D in 2018.
- Westinghouse sharply reduced its investment in SMRs after failing to secure US government funding.
- China is building a 210 MW demonstration high-temperature gas-cooled reactor but it is it is behind schedule and over-budget, and plans for additional high-temperature reactors at the same site have been "dropped" according to the World Nuclear Association.
- MidAmerican Energy gave up on its plans for SMRs in Iowa after failing to secure legislation that would require rate-payers to partially construction costs.

- Rolls-Royce sharply reduced its SMR investment in the UK to "a handful of salaries" and is threatening to abandon its R&D altogether unless massive subsidies are provided by the British government.
- TerraPower abandoned its plan for a prototype fast neutron reactor in China due to restrictions placed on nuclear trade with China by the Trump administration.
- The UK government abandoned consideration of 'integral fast reactors' for plutonium disposition in March 2019 (and the US government did the same in 2015).

The 'advanced' nuclear sector is regressing, not advancing. It is a high-risk sector, hence the deep reluctance of the private sector and national governments to invest.

The last Generation IV reactor to commence operation was a fast neutron reactor in Russia in 2014 but, as mentioned, Russia has postponed plans for a larger fast neutron reactor. The next Generation IV reactor to commence operation may be the long-delayed, over-budget 'Prototype Fast Breeder Reactor' (PFBR) in India. Construction of the reactor began in 2004 and it is almost a decade behind schedule. The PFBR has a blanket with thorium and uranium to breed fissile uranium-233 and plutonium respectively; in other words, it will be ideal for weapons production.

India plans to use fast reactors to produce weapon-grade plutonium for use as driver fuel in thorium reactors – plans which are highly problematic with respect to weapons proliferation and security as John Carlson, the former Director-General of the Australian Safeguards and Non-proliferation Office, has repeatedly noted.

There is nothing 'cleaner, safer and more efficient' about India's 'advanced' reactor program. On the contrary, it is dangerous and it fans regional tensions and proliferation risks – all the more so since India refuses to allow IAEA safeguards inspections of its 'advanced' nuclear power program.

Legislation banning nuclear power should be retained

Our organisations believe that federal and state legal prohibitions against the construction of nuclear power reactors have served Australia well and should be retained. We welcome the current bipartisan political consensus that these prudent prohibitions should be retained.

Legislation banning nuclear power has saved Australia from the huge costs associated with failed and failing reactor projects in Europe and North America, such as the Westinghouse AP1000 project in South Carolina that was abandoned after the expenditure of at least US$9 billion (A$13.4 billion). The South Carolina fiasco could so easily have been replicated in New South Wales – or any of Australia's states or territories – if not for the Howard Government's wise decision to enact legal prohibitions.

Legislation banning nuclear power should also be retained because nuclear power could not possibly pass any reasonable economic test. Nuclear power clearly fails the two economic tests set by Prime Minister Scott Morrison. Firstly, nuclear power could not possibly be introduced or maintained without huge taxpayer subsidies. Secondly, nuclear power would undoubtedly result in higher electricity prices.

Legislation banning nuclear power should also be retained because there is no social license to introduce nuclear power to Australia (as Dr. Switkowski acknowledged at the 29 August 2019 hearing of the federal nuclear inquiry). Opinion polls find that Australians are overwhelmingly opposed to a nuclear power reactor being built in their local vicinity (10–28% support, 55–73% opposition); and opinion polls find that support for renewable energy sources far exceeds support for nuclear power

(for example a 2015 IPSOS poll found 72–87% support for solar and wind power but just 26% support for nuclear power). As the Clean Energy Council notes in its submission to this inquiry, it would require "a minor miracle" to win community support for nuclear power in Australia.

Legislation banning nuclear power should also be retained because the pursuit of a nuclear power industry would almost certainly worsen patterns of disempowerment and dispossession that Australia's First Nations have experienced – and continue to experience – as a result of nuclear and uranium projects. To give one example (among many), the National Radioactive Waste Management Act dispossesses and disempowers Traditional Owners in many respects: the nomination of a site for a radioactive waste dump is valid even if Aboriginal owners were not consulted and did not give consent; the Act has sections which nullify State or Territory laws that protect archaeological or heritage values, including those which relate to Indigenous traditions; the Act curtails the application of Commonwealth laws including the Aboriginal and Torres Strait Islander Heritage Protection Act 1984 and the Native Title Act 1993 in the important site-selection stage; and the Native Title Act 1993 is expressly overridden in relation to land acquisition for a radioactive waste dump. Indeed, this issue has been so poorly prosecuted that our groups maintain that there is a pressing need for the federal Parliament to pause the current National Radioactive Waste Management Facility process pending the findings of a dedicated inquiry that explores all available options for the management of Australia's existing holdings of radioactive waste.

Legislation banning nuclear power should also be retained because no-one could possibly have any confidence that a satisfactory solution would be found for the long-term management of streams of low-, intermediate- and high-level nuclear waste resulting from a nuclear power program. Decades-long efforts to establish a repository and store for Australia's low- and intermediate-level radioactive wastes continue to flounder and are currently subject to legal and Human Rights Commission complaints and challenges, initiated by Traditional Owners of the affected sites in South Australia. Globally, no country has an operating repository for high-level nuclear waste. The United States has a deep underground repository for long-lived intermediate-level waste (the only operating deep underground repository worldwide) but it was closed from 2014–17 following a chemical explosion in an underground waste barrel. Safety standards and regulatory oversight fell away sharply within the first decade of operation of the US repository – a sobering reminder of the challenge of safely managing dangerous nuclear waste for millennia.

Legislation banning nuclear power should also be retained because the introduction of nuclear power would delay and undermine the development of effective, economic energy and climate policies based on renewable energy sources and energy efficiency. A December 2018 report by CSIRO and the Australian Energy Market Operator (AEMO) found that the cost of power from small modular reactors would be more than twice as expensive as power from wind and solar PV with some storage costs included (two hours of battery storage or six hours of pumped hydro storage). At the 29 August 2019 hearing of the federal nuclear inquiry, the AEMO foreshadowed the findings of its upcoming report. Alex Wonhas, AEMO's chief system design and engineering officer, said:
"What we find today at current technology cost is that unfirmed renewables in the form of wind and solar are effectively the cheapest form of energy production. If we look at firmed renewables, for example wind and solar firmed with pumped hydro energy storage, that cost, at current cost, is roughly comparable to new build gas or new build coal-fired generation. Given the learning rate effect that we have just discussed, our expectation is that renewables will further decrease in their cost, and therefore firmed renewables will well and truly become the lowest cost of generation for the NEM."

The path forward

A growing number of expert studies have mapped out viable, affordable scenarios for 100% renewable electricity generation in Australia.[1] Our organisations agree with the January 2019 statement issued by the Climate Council, comprising Australia's leading climate scientists and other policy experts. The Climate Council argued that nuclear power reactors "are not appropriate for Australia and probably never will be" and further stated:
"Nuclear power stations are highly controversial, can't be built under existing law in any Australian state or territory, are a more expensive source of power than renewable energy, and present significant challenges in terms of the storage and transport of nuclear waste, and use of water".

Notably, there are indications that conservative political opinion is shifting in the direction of promoting renewable energy generation and energy storage technologies. For example, the Queensland state Liberal National Party made a submission[2] to the current federal nuclear inquiry arguing for the retention of federal legislation banning nuclear power and that "Australia's rich renewable energy sources are more affordable and bring less risk than the elevated cost and risk associated with nuclear energy". The submission further states: "We would encourage the Committee to ensure an increased emphasis is placed on measures designed to encourage investment in renewable energy that creates green jobs and lowers electricity bills, both for consumers and industry, which does not include nuclear energy."

The NSW energy minister Matt Kean has recently urged Australia's investment community to drive the energy transition in the state, and predicts that renewables – couple with storage or gas generators – will replace the state's ageing coal plants.[3] Mr. Kean said: "Right now, the energy industry is telling me that [ageing coal] power stations will be replaced with renewable energy in combination with gas and emerging storage technologies. Not because governments are forcing that to happen, but because the economics are driving it." The minister pointed to the 19,285MW of large-scale renewable energy projects that have received planning approval, and he pointed to the fact that there are just 1,410 MW of new fossil-fuelled power stations in the development pipeline, mostly gas-fired generators.

Uranium mining

According to the Issues Paper prepared by the NSW Parliamentary Research Service for this inquiry, the only known uranium deposit in NSW is Toongi, near Dubbo. The Toongi uranium deposit is tiny compared to Olympic Dam in SA (51–171 times smaller according to figures provided in the Issues Paper). The Issues Paper notes that the Toongi deposit is equivalent to 0.2-0.8% of Australia's total Identified Resources of uranium. The Issues Paper further notes that no exploration licences have been issued despite the NSW Government lifting the ban on uranium exploration in 2012.

Clearly, there is no prospect of a uranium mining industry of any substance in NSW.

Our organisations believe that the current ban on uranium mining should be retained – and extended to once again include uranium prospecting/exploration.

[1] https://nuclear.foe.org.au/clean-energy-studies/#two
[2] https://www.aph.gov.au/DocumentStore.ashx?id=5c2cf4df-5ef7-420c-86f3-eee32033fa3f&subId=669992
[3] https://reneweconomy.com.au/nsw-energy-minister-says-renewables-and-storage-will-replace-old-coal-generators-94631/

The issue is divisive – a recent Roy Morgan poll found 41% support for and 41% opposition to exporting uranium to other countries for their nuclear power needs. The economic returns for overcoming that division and opposition would be pitiful and short-lived.

The uranium mining ban should be retained because the industry's poor track record with respect to environmental performance including mine-site rehabilitation (see section 10 of this submission; and for detailed information see Assoc. Prof. Gavin Mudd's submission #225 to the current federal nuclear inquiry).

The uranium mining ban should be retained because the international safeguards system (which aims to detect diversions of nuclear materials to weapons programs) is underfunded and inadequate (see section 11.1 in this submission).

The uranium mining ban should be retained because no country has found a solution to the legacy of high-level nuclear waste that would inevitably result from uranium mining and its use in reactors.

Nuclear waste

The Committee will be aware that successive federal governments have unsuccessfully attempted to impose a national nuclear waste 'facility' (repository for lower-level wastes and above-ground store for long-lived intermediate-level wastes) on divided and unwilling communities in various parts of regional Australia.

Our organisations recommend that the Committee recommend to the NSW Government and Parliament that the Uranium Mining and Nuclear Facilities (Prohibitions) Act should be amended to provide some protection against any future attempt by the Commonwealth to impose a national nuclear waste facility in NSW. Such a recommendation would be in line with the recommendation of the 2004 NSW Joint Select Committee on the Transportation and Storage of Nuclear Waste that, if certain other recommendations were not agreed to, 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 NSW (with the exception of an interim waste facility at Lucas Heights).

Recommendations

Our organisations recommend:

- That the current ban on uranium mining in NSW should be retained.
- That the current ban on uranium mining in NSW should be extended to once again include uranium prospecting/exploration.
- That the Committee recommend to the NSW government and Parliament that the Uranium Mining and Nuclear Facilities (Prohibitions) Act should be amended to provide some protection against any future attempt by the Commonwealth to impose a national nuclear waste facility in NSW.

2. ENERGY AFFORDABILITY AND RELIABILITY, ECONOMIC FEASIBILITY

"Nuclear construction on-time and on-budget? It's essentially never happened."
– Andrew J. Wittmann, financial analyst with Robert W. Baird & Co., 2017.[4]

2.1 An Australian perspective

Even the Australian Nuclear Association acknowledges that nuclear power reactors could not be built without taxpayer subsidies. Thus the proposal to introduce nuclear power fails the test that has been established by Prime Minister Scott Morrison.

Nuclear power is far more expensive than existing energy sources, including renewables, and therefore could not possibly contribute to efforts to reduce power prices. On the contrary, nuclear power would undoubtedly result in higher prices and thus fails the second test that has been established by the Prime Minister.

Prime Minister Morrison cited the 2006 Switkowski report when providing a sceptical response to a question about the economic viability of nuclear power for Australia. Nuclear costs have increased dramatically since 2006 (a negative learning curve – as discussed below and as discussed by Dr. Switkowski at the 29 August 2019 hearing of the federal nuclear inquiry[5]).

The 2006 Switkowski report estimated the cost of electricity from new reactors at A$40–65 per megawatt-hour (MWh). That is approximately one-quarter of current estimates. Lazard's November 2018 report on levelized costs of electricity gives these figures[6]:

- Nuclear: A$166–280/MWh (US$112–189)
- Wind: A$43–83/MWh (US$29–56)
- Utility-scale solar: A$55–68/MWh (US$36–46)
- Natural-gas combined-cycle: A$61–110/MWh (US$41–74)

In 2009, Dr. Switkowski said that the construction cost of a 1,000 MW power reactor Australia would be A$4–6 billion.[7] Again, that is approximately one-quarter of the current cost estimates for all reactors under construction in western Europe (and Scandinavia) and north America, with cost estimates of those reactors ranging from A$17.8–24 billion.

Peter Farley, a fellow of the Australian Institution of Engineers, wrote in early 2019:[8]
"As for nuclear the 2,200 MW Plant Vogtle [in the US] is costing US$25 billion plus financing costs, insurance and long term waste storage. For the full cost of US$30 billion, we could build 7,000 MW of wind, 7,000 MW of tracking solar, 10,000 MW of rooftop solar, 5,000MW of pumped hydro and 5,000 MW of batteries. That is why nuclear is irrelevant in Australia."

In its May 2016 Final Report, the South Australian Nuclear Fuel Cycle Royal Commission concluded:

[4] https://www.bloomberg.com/news/articles/2017-02-13/toshiba-s-nuclear-reactor-mess-winds-back-to-a-louisiana-swamp
[5] www.aph.gov.au/Parliamentary_Business/Committees/House/Environment_and_Energy/Nuclearenergy/Public_Hearings
[6] https://www.lazard.com/media/450784/lazards-levelized-cost-of-energy-version-120-vfinal.pdf
[7] https://www.theaustralian.com.au/opinion/a-clean-and-green-way-to-fuel-the-nation/news-story/92aabe042acb3ef3ffdbdfacc65631bf
[8] https://reneweconomy.com.au/how-did-wind-and-solar-perform-in-the-recent-heat-wave-40479/

"Taking into account the South Australian energy market characteristics and the cost of building and operating a range of nuclear power plants, the Commission has found it would not be commercially viable to develop a nuclear power plant in South Australia beyond 2030 under current market rules."[9]

The SA Nuclear Fuel Cycle Royal Commission was also sceptical about the prospects for small modular reactors (SMRs) in light of its economic analysis (see section 3.3 below). The Commission's Final Report identified numerous hurdles and uncertainties facing SMRs including:[10]

- SMRs have a relatively small electrical output, yet some costs including staffing may not decrease in proportion to the decreased output.
- SMRs have lower thermal efficiency than large reactors, which generally translates to higher fuel consumption and spent fuel volumes over the life of a reactor.
- SMR-specific safety analyses need to be undertaken to demonstrate their robustness, for example during seismic events.
- It is claimed that much of the SMR plant can be fabricated in a factory environment and transported to site for construction. However, it would be expensive to set up this facility and it would require multiple customers to commit to purchasing SMR plants to justify the investment.
- Reduced safety exclusion zones for small reactors have yet to be confirmed by regulators.
- Timescales and costs associated with the licensing process are still to be established.
- SMR designers need to raise the necessary funds to complete the development before a commercial trial of the developing designs can take place.
- Customers who are willing to take on first-of-a-kind technology risks must be secured.

2.2 Australian Energy Market Operator studies

According to a December 2018 report by the CSIRO and the Australian Energy Market Operator (AEMO), the cost of power from small modular reactors would be more than twice as expensive as power from wind and solar PV with some storage costs included (two hours of battery storage or six hours of pumped hydro storage).[11]

At the 29 August 2019 hearing of the federal nuclear inquiry, AEMO foreshadowed the findings of its forthcoming report. Alex Wonhas, AEMO's chief system design and engineering officer, told the Committee:[12]
"What we find today at current technology cost is that unfirmed renewables in the form of wind and solar are effectively the cheapest form of energy production. If we look at firmed renewables, for example wind and solar firmed with pumped hydro energy storage, that cost, at current cost, is roughly comparable to new build gas or new build coal-fired generation. Given the learning rate effect that we have just discussed, our expectation is that renewables will further decrease in their cost, and therefore firmed renewables will well and truly become the lowest cost of generation for the NEM."

Hopefully the next AEMO report will be completed in time for it to be considered by the Committee before concluding this inquiry.

[9] South Australian Nuclear Fuel Cycle Royal Commission Report, May 2016, http://yoursay.sa.gov.au/system/NFCRC_Final_Report_Web.pdf
[10] http://yoursay.sa.gov.au/system/NFCRC_Final_Report_Web.pdf
[11] https://www.csiro.au/~/media/News-releases/2018/renewables-cheapest-new-power/GenCost2018.pdf
[12] www.aph.gov.au/Parliamentary_Business/Committees/House/Environment_and_Energy/Nuclearenergy/Public_Hearings

2.3 Nuclear power's economics crisis

Supporters of nuclear power have issued any number of warnings[13] in recent years about nuclear power's "rapidly accelerating crisis"[14] and a "crisis that threatens the death of nuclear energy in the West"[15], while pondering what if anything might be salvaged from the "ashes of today's dying industry".[16]

Consider the following statements, many of them from nuclear industry insiders:

- "I don't think we're building any more nuclear plants in the United States. I don't think it's ever going to happen. They are too expensive to construct." – William Von Hoene, Senior Vice-President of Exelon (the largest operator of nuclear power plants in the US), 2018.[17]
- Nuclear power "just isn't economic, and it's not economic within a foreseeable time frame." – John Rowe, recently-retired CEO of Exelon, 2012.[18]
- "It's just hard to justify nuclear, really hard." – Jeffrey Immelt, General Electric's CEO, 2012.[19]
- "I don't think anybody's pretending you can take forward a new nuclear power station without some form of government underwriting or support." – Sir John Armitt, chair of the UK National Infrastructure Commission, 2018.[20]
- France's nuclear industry is in its "worst situation ever"[21], a former EDF director said in November 2016 – and the situation has worsened since then.[22]
- Nuclear power is "ridiculously expensive" and "uncompetitive" with solar. – Nobuo Tanaka, former executive director of the International Energy Agency, and former executive board member of the Japan Atomic Industrial Forum, 2018.[23]
- Compounding problems facing nuclear developers "add up to something of a crisis for the UK's nuclear new-build programme." – Tim Yeo, former Conservative parliamentarian and now a nuclear industry lobbyist, 2017.[24]
- "I don't think a CEO of a utility could in good conscience propose a nuclear-power reactor to his or her board of directors." – Alan Schriesheim, director emeritus of Argonne National Laboratory, 2014.[25]
- "New-build nuclear in the West is dead" due to "enormous costs, political and popular opposition, and regulatory uncertainty" – *Morningstar* market analysts Mark Barnett and Travis Miller, 2013[26]
- "The mooted nuclear renaissance has clearly stalled." – Steve Kidd, former World Nuclear Association executive, 2014.[27]

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[13] https://www.wiseinternational.org/nuclear-monitor/839/nuclear-power-crisis-or-it-merely-end
[14] http://www.environmentalprogress.org/big-news/2017/2/13/why-its-big-bet-on-westinghouse-nuclear-bankrupted-toshiba
[15] http://www.environmentalprogress.org/big-news/2017/2/16/nuclear-must-change-or-die
[16] https://thebreakthrough.org/index.php/voices/ted-nordhaus/the-end-of-the-nuclear-industry-as-we-know-it
[17] https://www.spglobal.com/platts/en/market-insights/latest-news/electric-power/041218-no-new-nuclear-units-will-be-built-in-us-due-to-high-cost-exelon-official
[18] https://www.forbes.com/sites/jeffmcmahon/2012/03/29/exelons-nuclear-guy-no-new-nukes/
[19] https://www.ft.com/content/60189878-d982-11e1-8529-00144feab49a
[20] https://www.theguardian.com/uk-news/2018/jul/10/nuclear-renewables-are-better-bet-ministers-told
[21] http://www.theguardian.com/environment/2016/nov/29/french-nuclear-power-worst-situation-ever-former-edf-director
[22] https://climatenewsnetwork.net/frances-nuclear-industry-struggles-on/
[23] http://www.asahi.com/ajw/articles/AJ201807240045.html
[24] www.telegraph.co.uk/business/2017/04/01/can-britains-nuclear-ambitions-avoid-meltdown/
[25] http://www.forbes.com/sites/jeffmcmahon/2014/12/09/another-giant-declares-nuclear-dead-in-fracking-america/
[26] https://www.forbes.com/sites/jeffmcmahon/2013/11/10/new-build-nuclear-is-dead-morningstar/
[27] https://www.neimagazine.com/opinion/opinionuranium-enrichment-whats-happening-today-4311115/

- "Nuclear power and solar photovoltaics both had their first recorded prices in 1956. Since then, the cost of nuclear power has gone up by a factor of three, and the cost of PV has dropped by a factor of 2,500." – J. Doyne Farmer, Oxford University economics professor, 2016.[28]

Even the International Atomic Energy Agency (IAEA) – which is tasked with promoting nuclear power – said in a September 2018 report that global nuclear power capacity "risks shrinking in the coming decades as ageing reactors are retired and the industry struggles with reduced competitiveness".[29] The IAEA's estimates for global nuclear power capacity in 2030 are 36% lower than the same estimates in 2010, the year before the Fukushima disaster.[30]

China is the only country with a significant nuclear new-build program. But China's nuclear power program has stalled twice over the past decade – after the 2011 Fukushima disaster and again in late 2016.[31] The most likely outcome over the next decade is that a small number of new reactor projects will be approved each year in China, well short of previous projections and not nearly enough to match the decline in the rest of the world. Currently, 46 reactors account for 4.2% of national electricity generation, with another 11 under construction. China's efforts to develop fast-breeder reactor technology have been unsuccessful, with one long-delayed, poorly-performing prototype reactor[32] and another demonstration reactor in the early stages of construction. Former World Nuclear Association executive Steve Kidd noted in August 2018 that the growth of renewables in China "dwarf the nuclear expansion" and that "many of the negative factors which have affected nuclear programmes elsewhere in the world are now also equally applicable in China."[33]

With the ageing of the current reactor fleet, it is becoming increasingly unlikely that new reactors will match shut-downs over the coming decades:

- The International Energy Agency expects a "wave of retirements of ageing nuclear reactors" and an "unprecedented rate of decommissioning" – almost 200 reactor shut-downs between 2014 and 2040.[34]
- The International Atomic Energy Agency (IAEA) anticipates 320 gigawatts (GW) of retirements (more than 80% of the worldwide total) from 2017 to 2050.[35]
- Another IAEA report estimates up to 139 GW of permanent shut-downs from 2018–2030 (more than one-third of the worldwide total) and up to 186 GW of further shut-downs from 2030–2050.[36]
- The reference scenario in the 2017 edition of the World Nuclear Association's *Nuclear Fuel Report* has 140 reactors closing by 2035.[37]

[28] https://www.popularmechanics.com/science/energy/a18818/can-us-nuclear-power-get-un-stuck/

[29] https://www.iaea.org/newscenter/pressreleases/new-iaea-energy-projections-see-possible-shrinking-role-for-nuclear-power

[30] https://www.wiseinternational.org/nuclear-monitor/866/new-iaea-report-sees-possible-shrinking-role-nuclear-power

[31] https://wiseinternational.org/nuclear-monitor/871/china-rescue

[32] https://www.wiseinternational.org/nuclear-monitor/831/slow-death-fast-reactors

[33] http://www.neimagazine.com/opinion/opinionnuclear-in-china-where-is-it-heading-now-6275899/

[34] International Energy Agency, 2014, 'World Energy Outlook 2014 Factsheet', www.iea.org/media/news/2014/press/141112_WEO_FactSheet_Nuclear.pdf

[35] International Atomic Energy Agency, 28 July 2017, 'International Status and Prospects for Nuclear Power 2017: Report by the Director General', www.iaea.org/About/Policy/GC/GC61/GC61InfDocuments/English/gc61inf-8_en.pdf

[36] International Atomic Energy Agency, 2018, 'Energy, Electricity and Nuclear Power Estimates for the Period up to 2050: 2018 Edition', https://www-pub.iaea.org/MTCD/Publications/PDF/RDS-1-38_web.pdf

[37] World Nuclear Association, 2017, 'The Nuclear Fuel Report', http://www.world-nuclear.org/our-association/publications/publications-for-sale/nuclear-fuel-report.aspx

2.4 Recent experience in the US and western Europe: new reactors cost A$17.8–24 billion each

The V.C. Summer project in South Carolina (two AP1000 reactors) was abandoned after the expenditure of at least A$13.4 billion (US$9 billion).[38] The project was initially estimated to cost A$17.1 billion (US$11.5 billion); when it was abandoned, the estimate was around A$37.2 billion (US$25 billion).[39] Largely as a result of the V.C. Summer disaster, Westinghouse filed for bankruptcy and its parent company Toshiba almost went bankrupt as well. Both companies have decided that they will no longer take on the huge risks associated with reactor construction projects.

The cost estimate for the Vogtle project in US state of Georgia (two AP1000 reactors) has doubled to A$40.2–44.6+ billion (US$27–30+ billion) and will increase further, and the project only survives because of multi-billion-dollar government bailouts.[40] In 2006, Westinghouse said it could build an AP1000 reactor for as little as A$2.0 billion (US$1.4 billion)[41] – 10 times lower than the current estimate for Vogtle.

In the UK, three of six proposed reactor projects have been abandoned (Moorside, Wylfa, Oldbury), two remain in limbo (Sizewell and Bradwell) and Hinkley Point C is at the early stages of construction. The estimated combined cost of the two EPR reactors at Hinkley Point, including finance costs, is A$48.0 billion (£26.7 billion – the EU's 2014 estimate of £24.5 billion[42] including finance, plus a £2.2 billion increase announced in July 2017[43]). A decade ago, the estimated construction cost for one EPR reactor in the UK was almost seven times lower at A$3.7 billion (£2.0 billion).[44]

The UK National Audit Office estimates that taxpayer subsidies for Hinkley Point – primarily in the form of a guaranteed payment of A$166/MWh (£92.5/MWh), indexed for inflation, for 35 years – will amount to A$55 billion[45], while other credible estimates put the figure as high as A$91 billion.[46]

Hitachi abandoned the Wylfa project in Wales after the estimated cost of the twin-reactor project had risen from A$28.0 billion to A$42.0 billion (¥2 trillion to ¥3 trillion).[47] Hitachi abandoned the project despite unprecedented offers from the UK government to take a one third equity stake in the project; to consider providing all of the required debt financing; and to consider providing a guarantee of a minimum payment per unit of electricity (expected to be about A$134/MWh (£75/MWh)).[48]

In France, one EPR reactor is under construction at Flamanville. It is seven years behind schedule and the estimated cost of A$17.8 billion (€10.9 billion) is more than three times the original estimate of A$5.4 billion (€3.3 billion).[49] The French Government plans to reduce nuclear power's share of electricity generation from approximately 75% to 50% by 2035.[50]

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[38] https://www.worldnuclearreport.org/Toshiba-Westinghouse-The-End-of-New-build-for-the-Largest-Historic-Nuclear.html
[39] https://www.nytimes.com/2017/07/31/climate/nuclear-power-project-canceled-in-south-carolina.html
[40] https://www.wiseinternational.org/nuclear-monitor/867/vogtles-reprieve-snatching-defeat-jaws-defeat
[41] https://www.nytimes.com/2006/07/16/magazine/16nuclear.html
[42] http://europa.eu/rapid/press-release_IP-14-1093_en.htm
[43] https://www.theguardian.com/uk-news/2017/jul/03/hinkley-point-c-is-22bn-over-budget-and-a-year-behind-schedule-edf-admits
[44] https://energypost.eu/saga-hinkley-point-c-europes-key-nuclear-decision/
[45] https://www.theguardian.com/uk-news/2016/jul/13/hinkley-point-c-cost-30bn-top-up-payments-nao-report
[46] http://www.no2nuclearpower.org.uk/wp/wp-content/uploads/2017/09/Time-to-Cancel-HinkleyFinal.pdf
[47] https://mainichi.jp/english/articles/20181225/p2a/00m/0na/011000c
[48] https://www.gov.uk/government/speeches/statement-on-suspension-of-work-on-thewylfa-newyddnuclear-project
[49] http://www.globalconstructionreview.com/news/frances-nuclear-regulator-finally-approves-flamanv/
[50] https://wiseinternational.org/nuclear-monitor/870/french-president-announces-energy-roadmap

In Finland, one EPR reactor is under construction. It is 10 years behind schedule and the estimated cost of A$17.9 billion (€11 billion) is more than three times the original A$4.9 billion (€3 billion) estimate.[51]

2.5 'Generation IV' and small modular reactor economics

Generation IV nuclear concepts were considered and rejected by the 2015/16 South Australian Nuclear Fuel Cycle Royal Commission. The Royal Commission said in its final report:[52]
"[A]dvanced fast reactors and other innovative reactor designs are unlikely to be feasible or viable in the foreseeable future. The development of such a first-of-a-kind project in South Australia would have high commercial and technical risk. Although prototype and demonstration reactors are operating, there is no licensed, commercially proven design. Development to that point would require substantial capital investment. Moreover, electricity generated from such reactors has not been demonstrated to be cost competitive with current light water reactor designs."

Most small modular reactors under construction are significantly over-budget. The economics of small modular reactors are summarised in section 3 of this submission and discussed in detail in a separate submission by Friends of the Earth Australia (submission #36[53]).

Historical experience is not promising. 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 an astonishing US$1,330/MWh.[54] Japan will have wasted over A$20 billion on its failed Monju fast neutron reactor once decommissioning is complete.[55]

2.6 Nuclear power'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.[56] 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."[57]

[51] https://www.worldnuclearreport.org/World-Nuclear-Industry-Status-Report-2018-HTML.html#lien21
[52] http://yoursay.sa.gov.au/system/NFCRC_Final_Report_Web.pdf
[53] https://www.aph.gov.au/DocumentStore.ashx?id=7a9318c0-aad6-405e-832f-66212a87d158&subId=669038
[54] Salahodeen Abdul-Kafi, 30 March 2011, 'The Superphénix Fast-Breeder Reactor', http://large.stanford.edu/courses/2011/ph241/abdul-kafi1/
[55] See Appendix 2 in the joint NGO submission to the federal nuclear inquiry, https://www.aph.gov.au/DocumentStore.ashx?id=9eee9d5f-4362-4b30-b0b8-3b65ff98215f&subId=670271
[56] 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/
[57] www.businessinsider.com.au/5-charts-that-show-nuclear-is-declining-2013-10

Even the large-scale, standardised French nuclear power program has been subject to a negative learning curve.[58] The problem of escalating costs is worsening with the massive cost blowouts associated with the EPR projects in France and Finland.

In 2009, an updated version of a 2003 MIT Interdisciplinary Study on the Future of Nuclear Power was published, stating:[59]
"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."

Note that these significant cost escalations were very much in evidence before the March 2011 Fukushima disaster.

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."[60]

Citigroup commented on three 'Corporate Killers' in a 2009 report:[61]
"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."

Thus Citigroup foreshadowed the bankruptcy filing of Westinghouse (and the near-bankruptcy of its parent company Toshiba), which resulted primarily from massive cost overruns at the V.C. Summer reactor project in South Carolina and the abandonment of that partially-completed project after the expenditure of at least A$13.4 billion (US$9 billion).

[58] 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
[59] http://web.mit.edu/nuclearpower/
[60] World Nuclear Association, 'The Economics of Nuclear Power', http://web.archive.org/web/20140212215105/www.world-nuclear.org/info/Economic-Aspects/Economics-of-Nuclear-Power/
[61] Citigroup, 9 Nov 2009, 'New Nuclear - the Economics Say No: UK Green Lights New Nuclear – Or Does It?', http://nonuclear.se/files/SEU27102.pdf

3. SMALL MODULAR REACTORS

3.1 Overview

A separate submission by Friends of the Earth Australia discusses small modular reactors (SMRs) in detail.[62] An overview is presented here.

It is generally accepted that no SMRs are in operation although there is a (mostly unsuccessful) history of small reactors being used for power generation and some small power reactors currently operate. Further, it is generally accepted that a small number of SMRs are under construction (four according to the IAEA; a couple more according to the World Nuclear Association). Those statements depend on definitions: it could be argued that no SMRs are under construction since none of the small reactors under construction are based on modular, factory construction.

There is a long history of small reactors being used for naval propulsion, but efforts to develop land-based SMRs have not been successful. Academic M.V. Ramana concludes an analysis of the history of SMRs as follows:[63]
"Sadly, the nuclear industry continues to practice selective remembrance and to push ideas that haven't worked. Once again, we see history repeating itself in today's claims for small reactors – that the demand will be large, that they will be cheap and quick to construct. But nothing in the history of small nuclear reactors suggests that they would be more economical than full-size ones. In fact, the record is pretty clear: Without exception, small reactors cost too much for the little electricity they produced, the result of both their low output and their poor performance. ... Worse, attempts to make them cheaper might end up exacerbating nuclear power's other problems: production of long-lived radioactive waste, linkage with nuclear weapons, and the occasional catastrophic accident."

Here is the list of SMRS under construction[64] (for the Russian floating power plant, construction is complete but operation has not yet commenced):

- Russia's floating power plant with twin ice-breaker-type reactors (2 x 35 MW). The primary purpose of the plant is to power fossil fuel mining operations in the Arctic.[65]
- Russia's RITM-200 icebreaker ships powered by twin reactors (2 x 50 MW). Two such ships are operating and a third is under construction. The vessels are intended for the Northern Sea Route along the Russian Arctic coast.
- Argentina's 32-MW CAREM PWR reactor (Argentina's national atomic energy agency claimed in 2014 that it was the first SMR in the world to be officially under construction).
- China's high-temperature gas-cooled reactor (twin reactors feeding a single turbine).
- China's ACPR50S demonstration reactor (50–60 MW). According to China's CGN: "The ACPR50S, designed for the marine environment as a floating nuclear power plant, will be used to provide stable, economical and green resources, such as electricity, heat and fresh water, for China's oilfield exploitation in the Bohai Sea and deep-water oil and gas development in the South China Sea."[66]

[62] https://www.aph.gov.au/DocumentStore.ashx?id=7a9318c0-aad6-405e-832f-66212a87d158&subId=669038
[63] M.V. Ramana, 27 April 2015, 'The Forgotten History of Small Nuclear Reactors', https://spectrum.ieee.org/tech-history/heroic-failures/the-forgotten-history-of-small-nuclear-reactors
[64] World Nuclear Association, Jan 2019, 'Small Nuclear Power Reactors', http://www.world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-power-reactors/small-nuclear-power-reactors.aspx
[65] Jan Haverkamp, 28 May 2018, 'World's first purpose-built floating nuclear plant Akademik Lomonosov reaches Murmansk', Nuclear Monitor #861, https://www.wiseinternational.org/nuclear-monitor/861/worlds-first-purpose-built-floating-nuclear-plant-akademik-lomonosov-reaches
[66] CGN, 'Small Modular Reactor', accessed 13 Feb 2019, http://en.cgnpc.com.cn/encgn/c100050/business_tt.shtml

The World Nuclear Association lists nine SMR projects "for near-term deployment – development well advanced"[67] but few if any of those projects will progress to construction.

Roughly half of the SMRs under construction are designed to facilitate access to fossil fuel resources in the Arctic, the South China Sea and elsewhere (Russia's floating power plant, Russia's RITM-200 icebreaker ships, and China's ACPR50S demonstration reactor).

There are many disturbing connections between SMR projects, weapons proliferation and militarism more generally (see sections 6–8 of the separate Friends of the Earth Australia submission[68]).

While there is a great deal of hype and rhetoric about SMRs from the nuclear industry and its enthusiasts, informed opinion is sceptical. For example:

- A 2014 report produced by *Nuclear Energy Insider*, drawing on interviews with more than 50 "leading specialists and decision makers", noted a "pervasive sense of pessimism" resulting from abandoned and scaled-back SMR programs.[69]
- A 2017 Lloyd's Register report was based on the insights of almost 600 professionals and experts from utilities, distributors, operators and equipment manufacturers.[70] The professionals and experts predict that SMRs have a "low likelihood of eventual take-up, and will have a minimal impact when they do arrive".[71]
- The UK's National Infrastructure Commission said in a 2018 report: "Smaller reactors are still at an early stage of development and their benefits remain speculative."[72]
- William Von Hoene, senior vice president at Exelon – the largest operator of nuclear power plants in the US – said last year: "Right now, the costs on the SMRs, in part because of the size and in part because of the security that's associated with any nuclear plant, are prohibitive."[73]
- Former World Nuclear Association executive Steve Kidd includes SMRs in a list of self-serving "myths" promoted by the nuclear industry. He states: "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 [large light-water reactors], 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 [operating and maintenance] costs are a concern. A substantial part of these are fixed, irrespective of the size of reactor."[74]

The SMR industry has suffered multiple set-backs:

- Babcock & Wilcox abandoned its mPower SMR project in the US despite receiving government funding of US$111 million.

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[67] World Nuclear Association, Jan 2019, 'Small Nuclear Power Reactors', http://www.world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-power-reactors/small-nuclear-power-reactors.aspx

[68] https://www.aph.gov.au/DocumentStore.ashx?id=7a9318c0-aad6-405e-832f-66212a87d158&subId=669038

[69] Nuclear Energy Insider, 2014, "Small Modular Reactors: An industry in terminal decline or on the brink of a comeback?", http://1.nuclearenergyinsider.com/LP=362

[70] Lloyd's Register, February 2017, 'Technology Radar – A Nuclear Perspective: Executive summary', https://www.lr.org/en/latest-news/technology-radar-low-carbon/

[71] World Nuclear News, 9 Feb 2017, Nuclear more competitive than fossil fuels: report', http://www.world-nuclear-news.org/EE-Nuclear-more-competitive-than-fossil-fuels-report-09021702.html

[72] National Infrastructure Commission, July 2018, 'National Infrastructure Assessment', www.nic.org.uk/wp-content/uploads/CCS001_CCS0618917350-001_NIC-NIA_Accessible.pdf

[73] Steven Dolley, 12 April 2018, 'No new nuclear units will be built in US due to high cost: Exelon official', https://www.spglobal.com/platts/en/market-insights/latest-news/electric-power/041218-no-new-nuclear-units-will-be-built-in-us-due-to-high-cost-exelon-official

[74] Steve Kidd, 11 June 2015, 'Nuclear myths – is the industry also guilty?', www.neimagazine.com/opinion/opinionnuclear-myths-is-the-industry-also-guilty-4598343/

- Transatomic Power gave up on its molten salt reactor R&D in 2018.
- Westinghouse sharply reduced its investment in SMRs after failing to secure US government funding.
- China is building a demonstration high-temperature gas-cooled reactor (it is behind schedule and over-budget) but plans for 18 additional HTGR reactors at the same site have been "dropped" according to the World Nuclear Association.[75]
- MidAmerican Energy gave up on its plans for SMRs in Iowa after failing to secure legislation that would require rate-payers to part-pay construction costs.
- Rolls-Royce sharply reduced its SMR investment in the UK to "a handful of salaries"[76] and is threatening to abandon[77] its R&D altogether unless massive grants are provided by the British government.[78]
- TerraPower abandoned its plan for a prototype reactor in China due to restrictions placed on nuclear trade with China by the Trump administration.[79]
- The French government is in the process of winding up its planned 100–200 MW ASTRID demonstration fast reactor due to funding constraints (partly due to massive cost overruns with another small reactor) and lack of interest in the pursuit of fast reactor technology (see Appendix 2 in the joint NGO submission to the federal nuclear inquiry for further details[80]).

There is nothing in the history of small reactors that would inspire any confidence in the likelihood of a significant SMR industry developing now. Further, the history of a number of proposed SMR sub-types has also been a history of failure:

- Fast neutron reactors have a deeply troubled history (see Appendix 2 in the joint NGO submission to the federal nuclear inquiry for details[81]).
- Nothing in the history of high-temperature gas-cooled reactors (HTGRs) suggests that they are likely to progress beyond the experimental stage (see Appendix 6 in the joint NGO submission to the federal nuclear inquiry for details[82]).
- The history of molten salt reactors is uninspiring, and a great deal of R&D needs to be done. The French Institute for Radiological Protection and Nuclear Safety states that there "is no likelihood of even an experimental or prototype MSR … being built during the first half of this century" let alone a factory-based production chain churning out MSRs in large numbers.[83] In 2013, Transatomic Power was promising that its 'Waste-Annihilating Molten-Salt Reactor' would deliver safer nuclear

[75] World Nuclear Association, 21 March 2016, 'First vessel installed in China's HTR-PM unit', http://www.world-nuclear-news.org/NN-First-vessel-installed-in-Chinas-HTR-PM-unit-2103164.html

[76] NucNet, 23 July 2018, 'Rolls-Royce 'Planning To Shut Down SMR Project Without Government Support', https://www.nucnet.org/news/rolls-royce-planning-to-shut-down-smr-project-without-government-support

[77] Adam Vaughan, 1 Oct 2018, 'Energy firms demand billions from UK taxpayer for mini reactors', https://www.theguardian.com/environment/2018/sep/30/energy-firms-demand-billions-from-uk-taxpayer-for-mini-reactors

[78] Steve Thomas et al., 2019, 'Prospects for Small Modular Reactors in the UK & Worldwide', https://www.nuclearconsult.com/wp/wp-content/uploads/2019/07/Prospects-for-SMRs-report-2.pdf

[79] Reuters, 2 Jan 2019, 'Bill Gates' nuclear venture hits snag amid U.S. restrictions on China deals: WSJ', https://www.reuters.com/article/us-terrapower-china/bill-gates-nuclear-venture-hits-snag-amid-us-restrictions-on-china-deals-wsj-idUSKCN1OV1S5

[80] See Appendix 2 in the joint NGO submission to the federal nuclear inquiry, https://www.aph.gov.au/DocumentStore.ashx?id=9eee9d5f-4362-4b30-b0b8-3b65ff98215f&subId=670271

[81] See Appendix 2 in the joint NGO submission to the federal nuclear inquiry, https://www.aph.gov.au/DocumentStore.ashx?id=9eee9d5f-4362-4b30-b0b8-3b65ff98215f&subId=670271

[82] See Appendix 2 in the joint NGO submission to the federal nuclear inquiry, https://www.aph.gov.au/DocumentStore.ashx?id=9eee9d5f-4362-4b30-b0b8-3b65ff98215f&subId=670271

[83] IRSN, 2015, 'Review of Generation IV Nuclear Energy Systems', https://www.irsn.fr/EN/newsroom/News/Documents/IRSN_Report-GenIV_04-2015.pdf

power at half the price of power from conventional, large reactors.[84] By the end of 2018, the company had given up on its 'waste-annihilating' claims, run out of money, and been dissolved.[85]

3.2 No-one wants to pay for SMRs

"The fact that a technology has not been deployed, which is not economically competitive and is seen by financiers as too risky to support is a market success, not a failure."[86]

No company, utility, consortium or national government is seriously considering building the massive supply chain that is the very essence of SMRs – mass, modular factory construction. Yet without that supply chain, SMRs will be expensive, bespoke curiosities.

In early 2019, Kevin Anderson, North American Project Director for Nuclear Energy Insider, said that there "is unprecedented growth in companies proposing design alternatives for the future of nuclear, but precious little progress in terms of market-ready solutions."[87] Anderson argued that it is time to convince investors that the SMR sector is ready for scale-up financing, but that this would not be easy: *"Even for those sympathetic, the collapse of projects such as V.C. Summer does little to convince financiers that this sector is mature and competent enough to deliver investable projects on time and at cost."*[88]

Dr. Ziggy Switkowski – who headed the Howard Government's nuclear review in 2006 – recently made a similar point. "Nobody's putting their money up'' to build SMRs, he noted, and thus "it is largely a debate for intellects and advocates because neither generators nor investors are interested because of the risk."[89] Dr. Switkowski also recently noted that no-one knows how a network of SMRs might work in Australia because no such network can be found "anywhere in the world at the moment".[90]

A 2018 US Department of Energy report states that about US$10 billion of government subsidies would be needed to deploy 6 GW of SMR capacity by 2035.[91] But there is no likelihood that the US government will subsidise the industry to that extent. To date, the US government has offered US$452 million to support private-sector SMR projects[92], of which US$111 million was wasted on the mPower project that was abandoned in 2017.[93]

Canadian Nuclear Laboratories has set the goal of siting a demonstration SMR at its Chalk River site by 2026. But serious discussions about paying for a demonstration SMR – let alone a fleet of SMRs – have

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[84] Kevin Bullis, 12 March 2013, 'Safer Nuclear Power, at Half the Price', http://www.technologyreview.com/news/512321/safer-nuclear-power-at-half-the-price/

[85] Nuclear Monitor #867, 15 Oct 2018, 'Transatomic Gen IV startup shuts down', https://wiseinternational.org/nuclear-monitor/867/nuclear-news-nuclear-monitor-867-15-october-2018

[86] Steve Thomas et al., 2019, 'Prospects for Small Modular Reactors in the UK & Worldwide', https://www.nuclearconsult.com/wp/wp-content/uploads/2019/07/Prospects-for-SMRs-report-2.pdf

[87] Nuclear Energy Insider, 2019, 'The time is now – build the investment case to scale SMR', https://www.nuclearenergyinsider.com/international-smr-advanced-reactor

[88] https://www.nuclearenergyinsider.com/international-smr-advanced-reactor

[89] https://www.afr.com/politics/federal/no-investment-appetite-for-nuclear-switkowski-20190805-p52dwv

[90] Public Hearing, 29 Aug 2019, 'Inquiry into the prerequisites for nuclear energy in Australia', https://www.aph.gov.au/Parliamentary_Business/Committees/House/Environment_and_Energy/Nuclearenergy/Public_Hearings

[91] Kutak Rock and Scully Capital for DOE's Office of Nuclear Energy, Oct 2018, 'Examination of Federal Financial Assistance in the Renewable Energy Market: Implications and Opportunities for Commercial Deployment of Small Modular Reactors', https://www.energy.gov/ne/downloads/report-examination-federal-financial-assistance-renewable-energy-market

[92] www.energy.gov/articles/energy-department-announces-new-funding-opportunity-innovative-small-modular-reactors

[93] https://wiseinternational.org/nuclear-monitor/872-873/mpower-obituary

not yet begun. The Canadian SMR Roadmap website simply states: "Appropriate risk sharing among governments, power utilities and industry will be necessary for SMR demonstration and deployment in Canada."[94]

In 2018, the UK Government agreed to provide £56 million towards the development and licensing of advanced modular reactor designs and £32 million towards advanced manufacturing research.[95] This year, the UK Government announced that it may provide up to £18 million to a consortium to help build a demonstration SMR along with up to £45 million to be invested in the second phase of the Advanced Modular Reactor program.[96] But those government grants are small change: companies seeking to pursue SMR projects in the UK want several billion pounds from the government to build a prototype SMR. As noted earlier, Rolls-Royce sharply reduced its SMR investment in the UK to "a handful of salaries" and is threatening to abandon its R&D altogether unless massive subsidies are provided by the British government.

State-run SMR programs – in Argentina, China, Russia, and South Korea – might have a better chance of steady and significant funding, but to date the investments in SMRs have been minuscule compared to investments in other energy programs. South Korea won't build any of its domestically-designed SMART SMRs in South Korea ("this is not practical or economic" according to the World Nuclear Association[97]). South Korea's plan to export SMART technology to Saudi Arabia is problematic given the Kingdom's suspected interest in pursuing a weapons program[98], and in any case the project may be in trouble.[99]

China and Argentina hope to develop a large export market for their high-temperature and small pressurised water reactors, respectively, but so far all they can point to are partially-built demonstration reactors that have been subject to major cost overruns and delays.

3.3 Independent economic assessments

Prime Minister Scott Morrison has set two tests for nuclear power: it must be able to stand on its own feet without government subsidies, and it must reduce household power bills. There isn't the slightest chance that nuclear power (including SMRs) could pass either test.

Electricity from SMRs will almost certainly cost more than that from large reactors because of diseconomies of scale: a 250 MW SMR will generate 25 percent as much power as a 1,000 MW reactor, but it will require more than 25 percent of the material inputs and staffing, and other costs including waste management and decommissioning will be proportionally higher.

Diseconomies of scale are certain. Offsetting cost-saving features are speculative. For example it is difficult to assess the benefit of modular factory production since no such factories exist and questions would inevitably arise such as whether the market is sufficiently large to yield the potential benefits of factory-line production – and whether a significant market could be sustained for any length of time. Elements of modular factory production were attempted with the V.C. Summer AP1000 project in

[94] https://smrroadmap.ca/
[95] Neil Ford, 18 July 2018, 'UK funding spurs advanced reactor R&D but application outlook needed', https://analysis.nuclearenergyinsider.com/uk-funding-spurs-advanced-reactor-rd-application-outlook-needed
[96] https://www.parliament.uk/business/publications/written-questions-answers-statements/written-statements/
[97] http://www.world-nuclear.org/information-library/country-profiles/countries-o-s/south-korea.aspx
[98] https://www.wiseinternational.org/nuclear-monitor/800/small-modular-reactors-chicken-and-egg-situation
[99] Jung Suk-yee, 16 Nov 2018, 'Small Modular Reactor Export from S. Korea in Jeopardy', http://www.businesskorea.co.kr/news/articleView.html?idxno=26628

South Carolina yet this project was abandoned after the expenditure of at least A$13.4 billion (US$9 billion).[100]

SMRs are "leading the way in cost" according to Tania Constable from the Minerals Council of Australia.[101] NSW Deputy Premier John Barilaro claims that SMRs "are becoming very affordable".[102] But despite this enthusiasm, independent economic assessments consistently find that electricity from SMRs will be more expensive than that from large reactors:

- A study by WSP / Parsons Brinckerhoff prepared for the 2015/16 South Australian Nuclear Fuel Cycle Royal Commission estimated costs of A$180–184 per megawatt-hour (MWh) for large light-water reactors, compared to A$198–225 for SMRs.[103]
- A December 2018 report by CSIRO and the Australian Energy Market Operator concluded that "solar and wind generation technologies are currently the lowest-cost ways to generate electricity for Australia, compared to any other new-build technology."[104] It found that electricity from SMRs would be more than twice as expensive as that from wind or solar power with storage costs included (two hours of battery storage or six hours of pumped hydro storage).
- A report by the consultancy firm Atkins for the UK Department for Business, Energy and Industrial Strategy found that electricity from the first SMR in the UK would be 30% more expensive than that from large reactors, because of diseconomies of scale and the costs of deploying first-of-a-kind technology.[105]
- A 2015 report by the International Energy Agency and the OECD Nuclear Energy Agency predicted that electricity from SMRs will be 50−100% more expensive than that from large reactors, although it holds out some hope that large-volume factory production could reduce costs.[106]

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[100] Richard Korman, 1 Nov 2017 'Witness to the Origins of a Huge Nuclear Construction Flop', Engineering News-Record, https://www.enr.com/articles/43325-witness-to-the-origins-of-a-huge-nuclear-construction-flop
SCANA and Santee Cooper, 6 May 2014, Letter to CB&I and Westinghouse Electric Corporation, https://bloximages.newyork1.vip.townnews.com/postandcourier.com/content/tncms/assets/v3/editorial/9/81/981c2f5a-a52e-11e7-a8b9-bb32b93afb23/59ce6d9b7e835.pdf.pdf
Ray Henry / Associated Press, 26 July 2014, 'Promises of Easier Nuclear Construction Fall Short', http://abcnews.go.com/US/wireStory/promises-easier-nuclear-construction-fall-short-24725848
Andrew Brown, 27 Aug 2017, 'Early signs of 'incompetence at every level' went unheeded as South Carolina rushed toward 'sexy' nuclear future', http://www.postandcourier.com/business/early-signs-of-incompetence-at-every-level-went-unheeded-as/article_b47acd2c-89a5-11e7-830a-9364c7e7b71b.html

[101] https://www.dailytelegraph.com.au/news/opinion/heatwaves-proof-positive-australia-needs-nuclear/news-story/5ac56694a4c8d09ff10d810c4eb583d1

[102] https://www.tenterfieldstar.com.au/story/6289951/is-nuclear-power-an-energy-solution-that-could-come-to-the-south-coast/?cs=7

[103] WSP / Parsons Brinckerhoff, Feb 2016, 'Quantitative analysis and initial business case – establishing a nuclear power plant and systems in South Australia', http://nuclearrc.sa.gov.au/app/uploads/2016/05/WSP-Parsons-Brinckerhoff-Report.pdf

[104] Report: https://www.csiro.au/~/media/News-releases/2018/renewables-cheapest-new-power/GenCost2018.pdf
Media release: https://www.csiro.au/en/News/News-releases/2018/Annual-update-finds-renewables-are-cheapest-new-build-power

[105] Atkins, 21 July 2016, 'SMR Techno-Economic Assessment Project 1: Comprehensive Analysis and Assessment Techno-Economic Assessment, Final Report, Volume 1, For The Department of Energy and Climate Change', https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/665197/TEA_Project_1_Vol_1_-_Comprehensive_Analysis_and_Assessment_SMRs.pdf

[106] International Energy Agency (IEA) and OECD Nuclear Energy Agency (NEA), 2015, 'Projected Costs of Generating Electricity':
Media release: https://www.iea.org/newsroom/news/2015/august/joint-iea-nea-report-details-plunge-in-costs-of-producing-electricity-from-renew.html
Executive Summary: https://www.iea.org/Textbase/npsum/ElecCost2015SUM.pdf
Full report: https://webstore.iea.org/projected-costs-of-generating-electricity-2015

- An article by four pro-nuclear researchers from Carnegie Mellon University's Department of Engineering and Public Policy, published in 2018 in the *Proceedings of the National Academy of Science*, considered options for the development of an SMR industry in the US. They concluded that it would not be economically viable on a commercial basis and could only be progressed if the industry received "several hundred billion dollars of direct and indirect subsidies" over the next several decades.[107]

SMR enthusiasts envisage a large market emerging in the coming years. A frequently cited 2014 report by the UK National Nuclear Laboratory estimates 65–85 gigawatts (GW) of installed SMR capacity by 2035.[108] The estimate is highly ambitious given that no SMRs are operating, most or all of the small number of SMRs under construction have been subject to delays and cost overruns, and both governments and the private sector have been reluctant to invest.

The OECD's Nuclear Energy Agency is far more circumspect and realistic: it estimates <1 GW to 21 GW of installed worldwide SMR capacity by 2035[109] (by which time, at the current rate of installation, an additional 2500–3000 GW of new renewable capacity will have been installed).

The likelihood that SMRs will find anything more than a small, niche market is vanishingly small. Indeed, even the likelihood of a small, niche market is questionable. There was a wave of enthusiasm for SMRs in the late 1980s. Senator Peter McGauran, the Coalition's energy spokesperson, said in 1989: "You would know that new-generation reactors with maximum safety features are now coming into use. They are small (from 250–400 MW) and fully automated …"[110] However that wave of enthusiasm came and went without a single SMR being built anywhere in the world, and there is no reason to believe that the current wave of enthusiasm will be more productive.

Will Davis, a consultant to the American Nuclear Society, said in 2014 that the SMR "universe [is] rife with press releases, but devoid of new concrete".[15] The same can be said in 2019: few concrete plans and even fewer concrete pours. Artists' impressions of SMRs are proliferating[111] but there is little appetite – from industry or governments – to invest in SMR construction projects because of their high risks and uncertain outcomes.

3.4 Cost overruns on SMR projects

SMR projects will not be immune from the major cost overruns that have crippled large reactor projects. Indeed, cost overruns have already become the norm for SMR projects.

Estimated construction costs for Russia's floating nuclear power plant (with two 35-MW ice-breaker-type reactors) have increased more than four-fold to over US$10 billion / GW (US$740 million / 70 MW).[112] A 2016 OECD Nuclear Energy Agency report said that electricity produced by the Russian floating plant is expected to cost about US$200/MWh, with the high cost due to large staffing

[107] M. Granger Morgan, Ahmed Abdulla, Michael J. Ford, and Michael Rath, July 2018 'US nuclear power: The vanishing low-carbon wedge', Proceedings of the National Academy of Science, https://www.pnas.org/content/115/28/7184
[108] UK National Nuclear Laboratory, December 2014, 'Small Modular Reactors (SMR) Feasibility Study', http://www.nnl.co.uk/media/1627/smr-feasibility-study-december-2014.pdf
[109] OECD Nuclear Energy Agency, 2016, 'Small Modular Reactors: Nuclear Energy Market Potential for Near-term Deployment', https://www.oecd-nea.org/ndd/pubs/2016/7213-smrs.pdf
[110] See p.34 in http://www.reasoninrevolt.net.au/objects/pdf/d2017.pdf
[111] https://wiseinternational.org/sites/default/files/NM872-873-final.pdf
[112] Charles Digges, 25 May 2015, 'New documents show cost of Russian floating nuclear power plant skyrockets', http://bellona.org/news/nuclear-issues/2015-05-new-documents-show-cost-russian-nuclear-power-plant-skyrockets

requirements, high fuel costs, and the resources required to maintain the barge and coastal infrastructure.[113]

The CAREM (Central Argentina de Elementos Modulares) SMR under construction in Argentina illustrates the gap between SMR rhetoric and reality. In 2004, when the CAREM reactor was in the planning stage, Argentina's Bariloche Atomic Center estimated an overnight cost of US$1 billion / GW for an integrated 300 MW plant.[114] By April 2017, with construction underway, the cost estimate had soared to US$21.9 billion / GW (US$700 million / 32 MW).[115] The CAREM project is years behind schedule and costs will likely increase further.

Little information is available on the cost of China's demonstration 210 MW high-temperature gas-cooled reactor (HTGR). The World Nuclear Association states that the construction cost is US$6,000 / kW.[116] The estimated construction cost is reportedly about twice the initial cost estimate, with increases due to higher material and component costs, increases in labour costs, and increased costs associated with project delays.[117] China's Institute of Nuclear and New Energy Technology at Tsinghua University expects the cost of a scaled-up 655 MW HTGR to be 15-20% higher than the cost of a conventional 600 MW pressurised water reactor.[118] Further feasibility studies are underway in China but plans for 18 additional HTGRs at the same site as the demonstration plant have been "dropped" according to the World Nuclear Association.[119]

3.5 NuScale Power's economic claims

The US company NuScale Power is targeting a cost of US$65/MWh for its first SMR plant.[120]

But a study by WSP / Parsons Brinckerhoff prepared for the SA Nuclear Fuel Cycle Royal Commission estimated a levelised cost of A$225/MWh (US$155/MWh) based on the NuScale design.[121]

Thus WSP / Parsons Brinckerhoff's independent estimate is 2.4 times higher than NuScale's estimate.

NuScale's cost estimates should be regarded as promotional and will continue to drop – unless and until the company actually builds an SMR plant. A 2015 NuScale report estimated a levelised cost of

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[113] OECD Nuclear Energy Agency, 2016, 'Small Modular Reactors: Nuclear Energy Market Potential for Near-term Deployment', https://www.oecd-nea.org/ndd/pubs/2016/7213-smrs.pdf

[114] Darío Delmastro, Marcelo Oscar Giménez et al., January 2004, 'CAREM concept: A competitive SMR', Conference Paper, Argentina's Bariloche Atomic Center, https://www.researchgate.net/publication/267579277_CAREM_concept_A_competitive_SMR

[115] Andrew Baker, 17 April, 'Argentine nuclear reactor due to start up in 2020', https://www.bnamericas.com/en/news/electricpower/argentine-nuclear-reactor-due-to-start-up-in-2020/

[116] World Nuclear Association, Feb 2019, 'Nuclear Power in China', http://www.world-nuclear.org/information-library/country-profiles/countries-a-f/china-nuclear-power.aspx

[117] 'China's plans to begin converting coal plants to walk away safe pebble bed nuclear starting in the 2020s', Dec 2016, http://www.nextbigfuture.com/2016/12/chinas-plans-to-begin-converting-coal.html

[118] World Nuclear Association, Feb 2019, 'Nuclear Power in China', http://www.world-nuclear.org/information-library/country-profiles/countries-a-f/china-nuclear-power.aspx

[119] World Nuclear Association, 21 March 2016, 'First vessel installed in China's HTR-PM unit', http://www.world-nuclear-news.org/NN-First-vessel-installed-in-Chinas-HTR-PM-unit-2103164.html

[120] https://www.powermag.com/nuscale-boosts-smr-capacity-making-it-cost-competitive-with-other-technologies/?printmode=1

[121] WSP / Parsons Brinckerhoff, Feb 2016, 'Quantitative analysis and initial business case – establishing a nuclear power plant and systems in South Australia', http://nuclearrc.sa.gov.au/app/uploads/2016/05/WSP-Parsons-Brinckerhoff-Report.pdf

US$98-$108/MWh.[122] By June 2018, the company said it is targeting a cost of just US$65/MWh for its first plant.[24] The company announced with some fanfare in 2018 that it had worked out how to make its SMRs almost 20% cheaper – by making them almost 20% bigger!

Lazard estimates costs of US$112–189/MWh for electricity from large nuclear plants.[123] NuScale's claim that its electricity will be 2–3 times cheaper than that from large nuclear plants is implausible. And even if NuScale achieved costs of US$65/MWh, that would still be higher than Lazard's figures for wind power (US$29–56) and utility-scale solar (US$36–46).

Likewise, NuScale's construction cost estimate of US$4.2 billion / GW is implausible.[124] The latest cost estimate for the two AP1000 reactors under construction in the US state of Georgia (the only reactors under construction in the US) is US$12.3–13.6 billion / GW.[125] NuScale's target is just one-third of that cost – despite the unavoidable diseconomies of scale and despite the fact that every independent assessment concludes that SMRs will be more expensive to build (per GW) than large reactors. Further, modular factory-line production techniques were trialled with the AP1000 reactor project in South Carolina – a project that was abandoned after the expenditure of at least US$9 billion.

3.6 SMR Nuclear Technology's economic claims

In support of its claim that "it is likely that SMRs will be Australia's lowest-cost generation source", SMR Nuclear Technology Pty Ltd cites[126] a 2017 report[127] by the US Energy Innovation Reform Project (EIRP). According to SMR Nuclear Technology, the EIRP study "found that the average levelised cost of electricity (LCOE) from advanced reactors was US$60/MWh."

However the cost figures used in the EIRP paper are nothing more than the optimistic estimates of companies hoping to get 'advanced' reactor designs off the ground. Therefore the EIRP authors heavily qualified the report's findings:[128]
"There is inherent and significant uncertainty in projecting NOAK [nth-of-a-kind] costs from a group of companies that have not yet built a single commercial-scale demonstration reactor, let alone a first commercial plant. Without a commercial-scale plant as a reference, it is difficult to reliably estimate the costs of building out the manufacturing capacity needed to achieve the NOAK costs being reported; many questions still remain unanswered – what scale of investments will be needed to launch the supply chain; what type of capacity building will be needed for the supply chain, and so forth."

SMR Nuclear Technology's conclusions – that "it is likely that SMRs will be Australia's lowest-cost generation source" and that low costs are "likely to make them a game-changer in Australia" – have no more credibility than the company estimates used in the EIRP paper. The US$60/MWh figure cited by SMR Nuclear Technology is far lower than all independent estimates for SMRs such as the

[122] Jay Surina (NuScale Chief Financial Officer), 20-21 August 2015, 'NuScale Plant Market: Competitiveness & Financeability', https://newsroom.nuscalepower.com/sites/nuscalepower.newshq.businesswire.com/files/press_release/additional/Jay_Surina_-_NuScale_Financial_Breakout_Session_0.pdf
[123] https://www.lazard.com/media/450784/lazards-levelized-cost-of-energy-version-120-vfinal.pdf
[124] https://www.powermag.com/nuscale-boosts-smr-capacity-making-it-cost-competitive-with-other-technologies/?printmode=1
[125] https://www.wiseinternational.org/nuclear-monitor/867/vogtles-reprieve-snatching-defeat-jaws-defeat
[126] www.parliament.nsw.gov.au/lcdocs/submissions/63873/0004%20SMR%20Nuclear%20Technology%20Pty%20Ltd.pdf
[127] Energy Innovation Reform Project, 2017, 'What Will Advanced Nuclear Power Plants Cost? A Standardized Cost Analysis of Advanced Nuclear Technologies in Commercial Development', report prepared by the Energy Options Network, https://www.innovationreform.org/wp-content/uploads/2018/01/Advanced-Nuclear-Reactors-Cost-Study.pdf
[128] ibid.

US$155/MWh (A$225/MWh) estimate in WSP / Parsons Brinckerhoff's study prepared for the SA Nuclear Fuel Cycle Royal Commission.[129]

SMR Nuclear Technology's assertion that "nuclear costs are coming down due to simpler and standardised design; factory-based manufacturing; modularisation; shorter construction time and enhanced financing techniques" is at odds with all available evidence and it is at odds with Dr. Ziggy Switkowski's observation that "costs per kilowatt hour appear to grow with each new generation of technology".[130]

SMR Nuclear Technology claims that failing to repeal federal legislative bans against nuclear power would come at "great cost to the economy". However the introduction of nuclear power to Australia would most likely have resulted in the major cost overruns and delays that have crippled every reactor construction project in the US and western Europe over the past decade. Nor is it likely that the outcome would have been positive if Australia had instead pursued SMR options. Reflecting on experience in the UK over the past decade, Thomas et al. state:[131]
"There is every likelihood that, as with the previous nuclear renaissance, SMRs will be still born with few reactors built. This will mean that public money will again have been wasted on nuclear technology, but, as previously, the main cost will be the opportunity costs of the options not pursued and properly funded because resources have been pre-empted by the nuclear sector."

3.7 NuScale Power's safety claims

Claims made about the safety of SMRs are routinely overstated (see section 9 in the separate Friends of the Earth Australia submission #36[132]).

Dr Edwin Lyman from the Union of Concerned Scientists (UCS) provides a reality check to claims made about NuScale Power's proposed SMRs:[133]

"As discussed in detail in my September 2013 report "Small Isn't Always Beautiful,"[134] UCS has safety and security concerns about small modular reactors in general and about the NuScale design in particular. SMR vendors are pushing the Nuclear Regulatory Commission (NRC) to weaken its regulations regarding operator staffing, security staffing, and emergency planning, based on highly optimistic assertions that their reactors will be significantly safer than larger reactors.

"NuScale raises issues because of its fundamental design: up to 12 reactor modules packed together in a swimming-pool type structure. The Fukushima disaster has shown the world the complexity of trying to manage multiple nuclear reactor accidents when crisis strikes, and it is far from obvious that the NuScale concept addresses this issue adequately. UCS also does not have confidence that the NRC's

[129] WSP / Parsons Brinckerhoff, Feb 2016, 'Quantitative analysis and initial business case – establishing a nuclear power plant and systems in South Australia', http://nuclearrc.sa.gov.au/app/uploads/2016/05/WSP-Parsons-Brinckerhoff-Report.pdf
[130] Public Hearing, 29 Aug 2019, 'Inquiry into the prerequisites for nuclear energy in Australia', https://www.aph.gov.au/Parliamentary_Business/Committees/House/Environment_and_Energy/Nuclearenergy/Public_Hearings
[131] Steve Thomas et al., 2019, 'Prospects for Small Modular Reactors in the UK & Worldwide', https://www.nuclearconsult.com/wp/wp-content/uploads/2019/07/Prospects-for-SMRs-report-2.pdf
[132] https://www.aph.gov.au/DocumentStore.ashx?id=7a9318c0-aad6-405e-832f-66212a87d158&subId=669038
[133] Ed Lyman, 17 Dec 2013, 'Safety and Security Concerns about Small Modular Reactors: NuScale's Design', https://allthingsnuclear.org/elyman/safety-and-security-concerns-about-small-modular-reactors-nuscales-design
[134] Edwin Lyman, Sept 2013, 'Small Isn't Always Beautiful: Safety, Security, and Cost Concerns about Small Modular Reactors', https://www.ucsusa.org/sites/default/files/legacy/assets/documents/nuclear_power/small-isnt-always-beautiful.pdf

licensing processes will give appropriate weight to multi-unit safety issues. Unfortunately, earlier this month the NRC staff concluded that safety concerns associated with "multiunit core damage events" did not warrant further evaluation in its "Generic Issues" program, which could have resulted in additional regulatory requirements.

"Many of the safety concerns described in the UCS report have now been validated by a Powerpoint presentation that was recently included, perhaps inadvertently, in the many thousands of pages of documents that the NRC has released under a Freedom of Information Act request for documents related to the Fukushima accident. The Powerpoint presentation, entitled "Center for Nuclear Waste Regulatory Analyses: Support to the U.S. Nuclear Regulatory Commission Office of New Reactors"[135] (p. 479-529) and dated March 24, 2011, describes safety issues for SMRs such as

- *Potential fire and explosion hazards: below-grade facilities present unique challenges, such as smoke/fire behavior; life safety; design and operation of the HVAC system and removal of waste water.*
- *Potential flooding hazards: below-grade reactors and subsystems raise concerns with regard to hurricane storm surges, tsunami run-up and water infiltration into structures.*
- *Limited access for conducting inspections of pressure vessels and components that are crucial for containing radiation, such as welds, steam generators, bolted connections and valves.*

"The document also spells out safety concerns particular to the NuScale design, observing that the reactors and spent fuel are stored in the same structure and depend on the same pool for cooling; that the bioshield covering the reactors or even the reactors themselves could be displaced in a flood; that the cooling pool could become contaminated with debris or other substances during a flood; and that operation under both normal and accident conditions depends highly on proper operation of valves around the pressure vessel.

"This document underscores the fact that SMRs are novel designs that raise new safety issues, and much analysis and testing will be required in order to verify the vendors' safety claims. There is therefore no basis at the present time for the NRC to grant SMRs any special exemptions to its regulatory requirements, and the Department of Energy should take steps to ensure that its Technical Licensing Support program does not use taxpayer funds to endanger public health by undermining nuclear safety and security standards."

[135] Southwest Research Institute, 'Center for Nuclear Waste Regulatory Analyses: Support to the U.S. Nuclear Regulatory Commission Office of New Reactors', http://pbadupws.nrc.gov/docs/ML1327/ML13270A404.pdf

4. GENERATION IV REACTOR CONCEPTS

Please also see relevant appendices in the joint NGO submission to the current federal inquiry:[136]
Appendix 2: Fast neutron reactors (a.k.a. fast spectrum or fast breeder reactors)
Appendix 3: Integral fast reactors (IFRs)
Appendix 4: Fusion scientist debunks fusion power
Appendix 5: Thorium
Appendix 6: High-temperature gas-cooled zombie reactors

4.1 Overview

It seems that each generation must learn anew that 'next generation' or 'Generation IV' concepts are not new and not promising and that most might best be described as failed Generation I concepts. Recent history is littered with Generation IV and small modular reactor (SMR) corpses. The Generation mPower SMR project in the US was abandoned.[137] Transatomic Power gave up on its molten salt reactor R&D.[138] MidAmerican Energy gave up on its plans for SMRs in Iowa after failing to secure legislation that would require rate-payers to part-pay construction costs.[139] Westinghouse sharply reduced its investment in SMRs after failing to secure US government funding.[140] TerraPower abandoned its plan for a prototype fast neutron reactor in China due to restrictions placed on nuclear trade with China by the Trump administration[141] and is struggling to attract financing elsewhere. Plans to use 'integral fast reactors' for surplus plutonium disposition have been rejected in both the UK and the US.

In the US, even if all the private-sector Generation IV R&D funding was pooled together (an estimated US$1.3 billion[142]), it is unlikely that it would suffice to build a single prototype reactor. An article by pro-nuclear researchers from Carnegie Mellon University's Department of Engineering and Public Policy, published in the *Proceedings of the National Academy of Science* in July 2018, argues that no US advanced reactor design will be commercialised before mid-century and that purported benefits remain "speculative".[143]

The US government has spent US$2 billion on Generation IV reactor R&D since the late 1990s "with very little to show for it" according to the Carnegie Mellon University researchers.[144] It is an option for the Australian government to pour billions into Generation IV R&D – but clearly it would not be a wise investment.

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[136] https://www.aph.gov.au/DocumentStore.ashx?id=9eee9d5f-4362-4b30-b0b8-3b65ff98215f&subId=670271
[137] https://wiseinternational.org/nuclear-monitor/872-873/mpower-obituary
[138] https://wiseinternational.org/nuclear-monitor/867/nuclear-news-nuclear-monitor-867-15-october-2018
[139] https://pauldeaton.com/2013/06/04/iowa-pulls-the-plug-on-nuclear-power/
[140] http://www.world-nuclear-news.org/NN-Westinghouse-SMR-progress-slows-210214ST.html
[141] Reuters, 2 Jan 2019, 'Bill Gates' nuclear venture hits snag amid U.S. restrictions on China deals: WSJ', https://www.reuters.com/article/us-terrapower-china/bill-gates-nuclear-venture-hits-snag-amid-us-restrictions-on-china-deals-wsj-idUSKCN1OV1S5
[142] M. Granger Morgan, Ahmed Abdulla, Michael J. Ford, and Michael Rath, July 2018 'US nuclear power: The vanishing low-carbon wedge', Proceedings of the National Academy of Science, http://www.pnas.org/content/early/2018/06/26/1804655115
[143] ibid.
[144] M. Granger Morgan, Ahmed Abdulla, Michael J. Ford, and Michael Rath, July 2018 'US nuclear power: The vanishing low-carbon wedge', Proceedings of the National Academy of Science, http://www.pnas.org/content/early/2018/06/26/1804655115
Media release, 2 July 2018, 'The vanishing nuclear industry', www.eurekalert.org/pub_releases/2018-07/coec-tvn062918.php

So-called Generation IV reactor concepts are diverse. Some are far from new – indeed most have been investigated for decades and have a troubled history. David Elliott – who worked initially with the UK Atomic Energy Authority and is now an Emeritus Professor at the Open University – has written a book about this troubled history.[145] In an article[146] discussing some themes taken up in his book, Elliot writes:

"While some nuclear enthusiasts hope that these Generation III reactors, like the EPR or its rivals, will be successful, there is also pressure to move on to new technology and so called Generation IV options, including liquid sodium-cooled fast neutron breeder reactors, helium-cooled high temperature reactors and thorium-fuelled molten salt reactors, at various scales. As I describe in my new book Nuclear Power: Past, Present and Future, many of them are in fact old ideas that were looked at in the early days and mostly abandoned. There were certainly problems with some of these early experimental reactors, some of them quite dramatic.

"Examples include the fire at the Simi Valley Sodium Reactor in 1959, and the explosion at the 3MW experimental SL-1 reactor at the US National Reactor Testing Site in Idaho in 1961, which killed three operators. Better known perhaps was and the core melt down of the Fermi Breeder reactor near Detroit in 1966. Sodium fires have been a major problem with many of the subsequent fast neutron reactor projects around the world, for example in France, Japan and Russia.

"For good or ill, ideas like this are back on the agenda, albeit in revised forms. … Fast neutron breeder reactors can produce new plutonium fuel from otherwise unused uranium-238 and may also be able to burn up some wastes, as in the Integral Fast Reactor concept and also the Traveling Wave Reactor variant. Molten Salt Reactors using thorium may be able to do this without producing plutonium or using liquid metals for cooling. Both approaches are being promoted, but both have problems, as was found in the early days. Certainly fast breeder reactors were subsequently mostly sidelined as expensive and unreliable. And as heightening nuclear weapons proliferation risks. The US gave up on them in the 1970s, France and the UK in the 1990s. Japan soldiered on, but has now abandoned its troubled Monju plant. For the moment it's mainly Russia that has continued, including with a molten lead cooled reactor, although India also has a fast reactor programme, linked to its thorium reactors plans.

"Thorium was used as a fuel for some reactors in some early experiments and is now being promoted again – there is more of it available globally than uranium. But there are problems. It isn't fissile, but neutrons, fast or slow, provided by uranium 235 or plutonium fission, can convert Thorium 232 into fissile U233. However, on the way to that, a very radioactive isotope, U232, is produced, which makes working with the fuel hard. Another isotope, U234 is also produced by neutron absorption. Ideally, to maximise U233 production, that should be avoided, but experts are apparently divided on whether this can be done effectively.

"The use of molten salts may help with some of these problems, perhaps making it easier to play with the nuclear chemistry and tap off unwanted by-products, but it is far from proven technically or economically. The economics is certainly challenging."

4.2 SA Nuclear Fuel Cycle Royal Commission

The SA Nuclear Fuel Cycle Royal Commission investigated claims made about Generation IV concepts and concluded in its May 2016 Final Report:[147]

"[A]dvanced fast reactors and other innovative reactor designs are unlikely to be feasible or viable in the foreseeable future. The development of such a first-of-a-kind project in South Australia would have

[145] David Elliott, May 2017, 'Nuclear Power: Past, Present and Future', Morgan & Claypool Publishers, http://bit.ly/2pIIX9Q
[146] David Elliott, 25 May 2017, 'Back to the future: old nukes for new', Nuclear Monitor #844, https://www.wiseinternational.org/nuclear-monitor/844/back-future-old-nukes-new
[147] http://yoursay.sa.gov.au/system/NFCRC_Final_Report_Web.pdf

high commercial and technical risk. Although prototype and demonstration reactors are operating, there is no licensed, commercially proven design. Development to that point would require substantial capital investment. Moreover, electricity generated from such reactors has not been demonstrated to be cost competitive with current light water reactor designs."

Little has changed since then – except the collapse of numerous Generation IV and SMR R&D projects.

4.3 Always decades away

Notwithstanding the history of (mostly failed) R&D projects, much work would need to be done to bring Generation IV concepts to commercial deployment.

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."[148]

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."[149] It could be argued that most or all of them are unlikely to reach commercial-scale deployment.

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."[150]

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."[151] The same could be said in 2019.

It should not be understood from the above statements that Generation IV systems will be commercialised in 2–3 decades. The point is that they are *always* 2–3 decades away. In general, R&D has not been promising and has been abandoned (either in the early stages, or following the failure of prototype reactors); R&D budgets are far too small to commercialise the concepts; and the pursuit of alternative energy sources has rightly been prioritised.

A 2015 report[152] by the French government's Institute for Radiological Protection and Nuclear Safety (IRSN) is of particular significance as it comes from a government which has invested heavily in nuclear technology. IRSN is a government authority with approximately 1,790 staff under the joint authority of the Ministries of Defense, the Environment, Industry, Research, and Health.

The IRSN 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

[148] www.gen-4.org/gif/jcms/c_9260/public
[149] www.gen-4.org/gif/jcms/c_41890/faq-2
[150] 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
[151] World Nuclear Association, 15 Dec 2009, 'Fast moves? Not exactly...', www.world-nuclear-news.org/NN_France_puts_into_future_nuclear_1512091.html
[152] 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

system chosen."[153] 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 (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".

4.4 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 (IRSN) reviewed the six concepts prioritised by the Generation IV International Forum and concluded:[154]
"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] ..."

Moreover the VHTR system could bring about significant safety improvements, the IRSN states, "but only by significantly limiting unit power".[155] The IRSN notes that it is difficult to thoroughly evaluate safety and radiation protection standards of Generation IV systems as some concepts have been partially tried and tested while others are still in the early stages of development.

The IRSN 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." The IRSN notes that ASN, the French nuclear safety authority, has announced that minor actinide transmutation would not be a deciding factor in the choice of a future reactor system. Those factors partly explain the French government's recent decision to abandon the 100–200 MW ASTRID demonstration fast neutron reactor project.

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 their resolution. The troubled history of fast reactors is detailed in a report by the International Panel on Fissile Materials[156] and in two appendices to the joint NGO submission to the federal nuclear inquiry (2. Fast Neutron Reactors; 3. Integral Fast Reactors).[157] Most of the countries that invested in fast reactor R&D have abandoned those efforts.

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[153] ibid.
[154] ibid.
[155] ibid.
[156] 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
[157] https://www.aph.gov.au/DocumentStore.ashx?id=9eee9d5f-4362-4b30-b0b8-3b65ff98215f&subId=670271

Regarding Generation IV concepts, Hirsch et al. state:[158]
"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 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."

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, former Director-General of the Australian Safeguards and Non-proliferation Office, writes:[159]
"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)."

There is nothing 'advanced' about India's 'advanced' breeder / thorium reactor program. On the contrary, it is dangerous and irresponsible, all the more so since India refuses to allow IAEA safeguards inspections of its fast reactor / thorium program.

4.5 US Government Accountability Office Report

In 2015, the US Government Accountability Office (GAO) released a report on the status of small modular reactors (SMRs) and other new reactor concepts in the US that concluded:[160]
"While light water SMRs and advanced reactors may provide some benefits, their development and deployment face a number of challenges. Both SMRs and advanced reactors require additional technical and engineering work to demonstrate reactor safety and economics, although light water SMRs generally face fewer technical challenges than advanced reactors because of their similarities to the existing large LWR [light water] reactors. Depending on how they are resolved, these technical challenges may result in higher-cost reactors than anticipated, making them less competitive with large LWRs or power plants using other fuels. ...
"Both light water SMRs and advanced reactors face additional challenges related to the time, cost, and uncertainty associated with developing, certifying or licensing, and deploying new reactor technology, with advanced reactor designs generally facing greater challenges than light water SMR designs. It is a

[158] 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, https://www.researchgate.net/publication/262630918

[159] John Carlson, 2014, first submission to Joint Standing Committee on Treaties, inquiry into Australia−India Nuclear Cooperation Agreement, Parliament of Australia, https://www.aph.gov.au/DocumentStore.ashx?id=79a1a29e-5691-4299-8923-06e633780d4b&subId=301365
See also: John Carlson, 2015, supplementary submission to Joint Standing Committee on Treaties, 'Suggested revisions to the text of 5 September 2014, as requested by JSCOT at the hearing of 9 February 2015', https://www.aph.gov.au/DocumentStore.ashx?id=242f5715-24fd-4b3e-8a4f-4c30651d1dc4&subId=301365

[160] US Government Accountability Office, July 2015, 'Nuclear Reactors: Status and challenges in development and deployment of new commercial concepts', GAO-15-652, www.gao.gov/assets/680/671686.pdf

multi-decade process, with costs up to $1 billion to $2 billion, to design and certify or license the reactor design, and there is an additional construction cost of several billion dollars more per power plant. "Furthermore, the licensing process can have uncertainties associated with it, particularly for advanced reactor designs. A reactor designer would need to obtain investors or otherwise commit to this development cost years in advance of when the reactor design would be certified or available for licensing and construction, making demand (and customers) for the reactor uncertain. For example, the price of competing power production facilities may make a nuclear plant unattractive without favorable rates set by a public authority or long term prior purchase agreements, and accidents such as Fukushima as well as the ongoing need for a long-term solution for spent nuclear fuel may affect the public perception of reactor safety. These challenges will need to be addressed if the capabilities and diversification of energy sources that light water SMRs and advanced reactors can provide are to be realized."

Many of the same reasons explain the failure of the Next Generation Nuclear Plant (NGNP) Project. Under the Energy Policy Act of 2005, the US Department of Energy (DOE) was to deploy a prototype 'next generation' reactor using advanced technology to generate electricity and/or hydrogen by the end of fiscal year 2021. The project was initiated in 2005 but the DOE decided not to proceed with it in 2011, citing an impasse between the DOE and the NGNP Industry Alliance regarding cost-sharing arrangements.[161]

According to the GAO report, SMRs and new reactor concepts "face some common challenges such as long time frames and high costs associated with the shift from development to deployment − that is, in the construction of the first commercial reactors of a particular type."

Advanced reactor designers told the GAO that they have been challenged to find investors due to the lengthy timeframe, high costs, and uncertainty. Advanced reactor concepts face greater technical challenges than light water SMRs because of fundamental design differences.

4.6 False arguments advanced by ANSTO in support of participation in the Generation IV International Forum

Comments made in ANSTO's 'National Interest Analysis' (NIA)[162] justifying Australian participation in the Generation IV International Forum (GIF) include false and tenuous arguments, some of which are briefly discussed here.

The NIA asserts that participation in the (GIF) will further Australia's non-proliferation and nuclear safety objectives. No evidence is supplied to justify that tenuous assertion. There is much else that Australia could do – but is not doing – that would demonstrably further non-proliferation objectives, e.g.

- A ban on reprocessing of Australian Obligated Nuclear Materials (AONM).
- A reversal of the decision to permit uranium sales to countries that have not signed or ratified the NPT or who are not compliant with their NPT disarmament obligations.
- Refusing uranium sales to countries that refuse to sign or ratify the Comprehensive Test Ban Treaty.
- Constructively addressing the flaws and underfunding of the IAEA safeguards system.

[161] Nuclear Regulatory Commission, accessed 20 May 2019, 'Next Generation Nuclear Plant (NGNP)', https://www.nrc.gov/reactors/new-reactors/advanced/ngnp.html

[162] http://www.aph.gov.au/~/media/02%20Parliamentary%20Business/24%20Committees/244%20Joint%20Committees/JSCT/2017/Nuclear%20Energy/ATNIA%2013.pdf?la=en

Nuclear non-proliferation objectives would also be far better realised by Australian ratification of the UN Treaty on the Prohibition of Nuclear Weapons, rather than participation in GIF. Instead, Australia has spurned and undermined this important weapons ban treaty.

There is much else that Australia could do – but is not doing – that would demonstrably further safety objectives, including:

- Insisting that uranium customer countries establish a strong, independent regulatory regime (as opposed to the inadequate regulation in a number of customer countries, e.g. China[163], India[164], Russia[165], the US[166], Japan[167], South Korea[168], and others).
- Revisiting the decision to sell uranium to Ukraine in light of the ongoing conflict in that country and serious safety and regulatory inadequacies.[169]
- Giving effect to the recommendations of the United Nations system-wide study on the implications of the accident at the Fukushima Daiichi nuclear power plant (September 2011).[170]

The NIA states that ongoing participation in GIF will help Australia maintain its permanent position on the IAEA's 35-member Board of Governors. ANSTO routinely makes such arguments – in support of the construction of the OPAL reactor, in support of the development of nuclear power in Australia, and now in support of Australian participation in GIF. Australia has held a permanent position on the IAEA's Board of Governors for decades and there is no reason to believe that participation or non-participation in GIF will change that situation. Further, the importance of that permanent position is often overstated.

The NIA states that ongoing participation in GIF "will improve the Australian Government's awareness and understanding of nuclear energy developments throughout the region and around the world, and contribute to the ability of the Australian Nuclear Science and Technology Organisation (ANSTO) to continue to provide timely and comprehensive advice on nuclear issues." Those arguments are tenuous: little or no information will be obtained through GIF participation that would not otherwise be available.

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[163] Emma Graham-Harrison, 25 May 2015, 'China warned over 'insane' plans for new nuclear power plants', https://www.theguardian.com/world/2015/may/25/china-nuclear-power-plants-expansion-he-zuoxiu

[164] A. Gopalakrishnan, 13 Nov 2017, 'India Should Halt Further Expansion of its Nuclear Power Program', The Citizen, https://www.thecitizen.in/index.php/en/NewsDetail/index/2/12239/India-Should-Halt-Further-Expansion-of-its-Nuclear-Power-Program

[165] Vladimir Slivyak, 2014, 'Russian Nuclear Industry Overview', https://ecdru.files.wordpress.com/2017/04/russian-nuc-ind-overviewrgb.pdf

[166] Edwin Lyman, 29 Aug 2019, 'Aging nuclear plants, industry cost-cutting, and reduced safety oversight: a dangerous mix', https://thebulletin.org/2019/08/aging-nuclear-plants-industry-cost-cutting-and-reduced-safety-oversight-a-dangerous-mix/ Gregory Jaczko, 17 May 2019, 'I Oversaw the US Nuclear Power Industry. Now I Think It Should Be Banned', https://www.commondreams.org/views/2019/05/17/i-oversaw-us-nuclear-power-industry-now-i-think-it-should-be-banned

[167] Nuclear Monitor #800, 19 March 2015, 'Japan's 'nuclear village' reasserting control', www.wiseinternational.org/nuclear-monitor/800/japans-nuclear-village-reasserting-control

[168] Nuclear Monitor #844, 25 May 2017, 'South Korea's 'nuclear mafia'', www.wiseinternational.org/nuclear-monitor/844/south-koreas-nuclear-mafia

[169] L. Todd Wood, 30 March 2017, 'Ukrainian corruption casts nuclear pall over Europe', http://www.washingtontimes.com/news/2017/mar/30/ukrainian-corruption-casts-nuclear-pall-over-all-e/ Nuclear Monitor #832, 19 Oct 2016, 'Ukraine's nuclear power program going from bad to worse', https://www.wiseinternational.org/nuclear-monitor/832/ukraines-nuclear-power-program-going-bad-worse

[170] https://www.un.org/ga/search/view_doc.asp?symbol=SG/HLM/2011/1

The NIA states that "Generation IV designs will use fuel more efficiently, reduce waste production, be economically competitive, and meet stringent standards of safety and proliferation resistance." Those false, promotional claims are refuted throughout this submission (sections 3–5, see also appendices 2–6 in the joint NGO submission to the federal nuclear inquiry[171]).

4.7 Generation IV concepts and nuclear waste

These issues are discussed in section 5.5 of this submission.

4.8 Generation IV concepts and nuclear weapons proliferation

Advocates of every conceivable type of reactor claim that their preferred reactor type is proliferation-proof or proliferation-resistant.

A thorium enthusiast claims that thorium is "thoroughly useless for making nuclear weapons."[172] 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.[173]

An enthusiast of integral fast reactors (IFR) claims they "cannot be used to generate weapons-grade material."[174] But IFRs *can* be used to produce plutonium for weapons – or at least they could be used to produce plutonium for weapons if they existed. 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."[175]

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."[176]

Fusion scientist Dr. Daniel Jassby discusses the proliferation risks associated with fusion concepts in a 2017 article in the *Bulletin of the Atomic Scientists*.[177]

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

[171] https://www.aph.gov.au/DocumentStore.ashx?id=9eee9d5f-4362-4b30-b0b8-3b65ff98215f&subId=670271
[172] Tim Dean, 16 March 2011, 'The greener nuclear alternative', https://www.abc.net.au/news/2011-03-16/thoriumdean/45178
[173] 'Thor-bores and uro-sceptics: thorium's friendly fire', Nuclear Monitor #801, 9 April 2015, https://www.wiseinternational.org/nuclear-monitor/801/thor-bores-and-uro-sceptics-thoriums-friendly-fire
[174] Barry Brook, 9 June 2009, 'An inconvenient solution', The Australian, http://bravenewclimate.com/2009/06/11/an-inconvenient-solution/
[175] George Stanford, 18 Sep 2010, 'IFR FaD 7 – Q&A on Integral Fast Reactors', http://bravenewclimate.com/2010/09/18/ifr-fad-7/
[176] Khidhir Hamza, Sep/Oct 1998, 'Inside Saddam's Secret Nuclear Program', Bulletin of the Atomic Scientists, Vol. 54, No. 5, https://books.google.com.au/books?id=rwsAAAAAMBAJ
[177] Daniel Jassby, 19 April 2017, 'Fusion reactors: Not what they're cracked up to be', Bulletin of the Atomic Scientists, https://thebulletin.org/2017/04/fusion-reactors-not-what-theyre-cracked-up-to-be/

and technology and in civil and military applications cannot be eliminated."[178] 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".[179]

[178] UK Royal Society, 13 Oct 2011, 'Fuel cycle stewardship in a nuclear renaissance', http://royalsociety.org/policy/projects/nuclear-non-proliferation/report

[179] John Carlson, 2009, 'Introduction to the Concept of Proliferation Resistance', www.foe.org.au/sites/default/files/Carlson%20ASNO%20ICNND%20Prolif%20Resistance.doc or http://archive.foe.org.au/sites/default/files/Carlson%20ASNO%20ICNND%20Prolif%20Resistance.doc

5. WASTE MANAGEMENT, TRANSPORT AND STORAGE

5.1 Introduction

"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." – nuclear engineer Alan Parkinson.[180]

The 2006 Switkowski (UMPNER) report 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 nuclear waste]."[181]

In the mid- to late-2000s, Dr. Ziggy Switkowski, former Chair of the Board of the Australian Nuclear Science and Technology Organisation and head of the UMPNER Review, was promoting the construction of as many as 50 nuclear power reactors in Australia.[182] Over a 50-year lifespan, a 50-reactor (50-gigawatt) nuclear power program would:[183]

- 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.

A demonstrated ability to manage Australia's current radioactive waste challenges would be necessary to establish confidence that Australia could manage the streams of radioactive and nuclear wastes arising from a nuclear power program.

However, Australia's current radioactive waste challenges are either being mismanaged or not managed at all:
1. Previous governments failed in their attempts to impose a national radioactive waste repository and store on unwilling communities in SA (1998–2004) and the NT (2005–2014).
2. The current push to establish a national radioactive waste repository and store in SA is strongly contested and aspects of the proposal are currently subject to legal challenges and a Human Rights Commission complaint, initiated by Traditional Owners of the targeted sites.

[180] Alan Parkinson, 2002, 'Double standards with radioactive waste', *Australasian Science*, https://nuclear.foe.org.au/flawed-clean-up-of-maralinga/
[181] Switkowski Review, 2006, Uranium Mining, Processing and Nuclear Energy Review, http://pandora.nla.gov.au/tep/66043
[182] 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
[183] Based primarily on figures in the UMPNER report. For information on the calculations for uranium tailings waste, see: 'There's No Nuclear Power Without Waste', 3 Dec 2010, http://web.archive.org/web/20130117002550/http://newmatilda.com/2010/12/03/theres-no-nuclear-power-without-waste

3. The management of radioactive tailings waste at past and current uranium mines has been deficient in many respects.[184] Cases in point here include continuing contamination concerns at both Mary Kathleen (Queensland) and Rum Jungle (NT).
4. At the former uranium mine at Radium Hill in SA, a radioactive waste repository "is not engineered to a standard consistent with current internationally accepted practice" according to a 2003 SA government audit.[185]
5. The Port Pirie uranium treatment plant in SA is still contaminated over 50 years after its closure.[186] It took a six-year community campaign just to get the site fenced off and to carry out a partial rehabilitation. As of July 2015, the SA government's website stated that "a long-term management strategy for the former site" is being developed.
6. SA regulators failed to detect Marathon Resource's illegal dumping of low-level radioactive waste in the Arkaroola Wilderness Sanctuary.[187] If not for the detective work of the managers of the Sanctuary, the illegal activities would never have been detected. The incident represents a serious failure of SA government regulation.
7. The 'clean-up' of nuclear waste at the Maralinga nuclear test site in the late 1990s was mismanaged and breached Australian and international standards regarding the disposal of long-lived radioactive waste.[188] Four scientists with first-hand information were highly critical of the 'clean up'.[189]
8. CSIRO faces a $30 million clean-up bill after barrels of radioactive waste at Woomera were found to be "deteriorating rapidly" and possibly leaking. An inspection found "significant rusting" of many of the 9,725 drums. An ARPANSA report found that the mixture of water and concentrated radioactive material inside some of the drums has the potential to produce explosive hydrogen gas.[190]

Former Liberal Party Senator Nick Minchin has commented on the difficulty of managing wastes from a nuclear power program:[191]
''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."

Likewise, current Federal Resources Minister Senator Matt Canavan noted in June 2019:[192]
"We have been trying for 40 years to find a long-term repository for radioactive waste that is produced at Lucas Heights and some legacy waste we have from other activities. If we can't find a permanent home for low-level radioactive waste associated with nuclear medicines, we've got a pretty big challenge dealing with the high-level waste that would be produced by any energy facilities."

5.2 Global challenges with nuclear waste

There are no operating repositories for high-level nuclear waste anywhere in the world. The one and only deep underground repository for long-lived intermediate-level waste − the Waste Isolation Pilot

[184] See section 1.11 (p.74) in the joint submission to the SA Nuclear Fuel Cycle Royal Commission, https://nuclear.foe.org.au/wp-content/uploads/NFCRC-submission-FoEA-ACF-CCSA-FINAL-AUGUST-2015.pdf
[185] See section 3.2 (p.11) in the joint submission to the SA Nuclear Fuel Cycle Royal Commission, https://nuclear.foe.org.au/wp-content/uploads/NFCRC-submission-FoEA-ACF-CCSA-FINAL-AUGUST-2015.pdf
[186] Ibid.
[187] Ibid.
[188] Numerous articles on the flawed 'clean up' are posted at https://nuclear.foe.org.au/flawed-clean-up-of-maralinga/
[189] https://nuclear.foe.org.au/flawed-clean-up-of-maralinga/
[190] See the information posted at https://nuclear.foe.org.au/woomera/
[191] Brad Crouch, 21 May 2006, 'No nuke plant in 100 years', *The Advertiser*.
[192] Matthew Killoran, 21 June 2019, 'What a waste: Minister's question for nuclear inquiry', The Courier-Mail, https://www.couriermail.com.au/news/queensland/queensland-government/what-a-waste-ministers-question-for-nuclear-inquiry/news-story/b5dcfdcd0e81653c22137934d28a799b

Plant in the US – was shut for three years following a chemical explosion in an underground waste barrel.

Finland and Sweden are the countries most advanced with deep geological repository projects. However the planned high-level nuclear waste repository in Finland is years behind schedule. The planned high-level nuclear waste repository in Sweden has hit a snag with the Swedish Land and Environmental Court ruling that SKB's application can only be approved if *"SKB can provide documentation that shows the final storage facility complies in the long-term with requirements of the Environmental Code despite the uncertainties remaining on how the canisters protective capability is effected by a) corrosion due to reaction in oxygen-free water"* and four other issues regarding copper corrosion, including the influence of radiation on three additional variables. Amongst other things, SKB has not carried out corrosion tests with a canister containing spent fuel.[193]

Other countries operating nuclear power plants – including the US, the UK, Japan, South Korea, Germany, etc. – have not even established a site for a high-level nuclear waste repository, let alone commenced construction or operation. To give one example of a protracted, expensive and failed attempt to establish a high-level nuclear waste repository, plans for a repository at Yucca Mountain in Nevada were abandoned in 2009 – and current attempts to revive the project are being strongly contested. Over 20 years of work was put into the repository plan and well over A$10 billion wasted on the failed project. 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 further controversy.[194]

A January 2019 report details the difficulties with high-level nuclear waste management in seven countries (Belgium, France, Japan, Sweden, Finland, the UK and the US) and serves as a useful overview of the serious problems that Australia has avoided by eschewing nuclear power.[195]

5.3 Long-term costs of high-level nuclear waste management

Estimated construction costs for high-level nuclear waste repositories are in the tens of billions of dollars and cost estimates have increased dramatically.[196] For example, the construction cost estimate in France was €25 billion (A$41.1 billion) as of 2016, well above the 2005 estimate of €13.5–16.5 billion (A$22.1–27.1 billion).[197]

The UK provides another example of dramatic escalations of cost estimates. 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$101.5 billion) to over £100 billion (A$181.3 billion).[198]

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[193] Miles Goldstick, 29 Jan 2018, 'Swedish nuclear industry loses battle over repository but battle rages on', https://www.wiseinternational.org/nuclear-monitor/856/swedish-nuclear-industry-loses-battle-over-repository-battle-rages

[194] Nuclear Information & Resource Service, http://archives.nirs.us/radwaste/yucca/yuccahome.htm

[195] Robert Alvarez, Hideyuki Ban, Charles Laponche, Miles Goldstick, Pete Roche and Bertrand Thuillier, Jan 2019, 'Report - The Global Crisis of Nuclear Waste', https://www.greenpeace.fr/report-the-global-crisis-of-nuclear-waste/

[196] Ibid.

[197] World Nuclear Association, http://www.world-nuclear-news.org/WR-Minister-sets-benchmark-cost-for-French-repository-1801165.html

[198] Jonathan Leake, 9 Dec 2012, 'Nuclear cleanup to take 120 years and cost £100bn', https://www.thetimes.co.uk/article/nuclear-cleanup-to-take-120-years-and-cost-pound100bn-qmmczbh5rft

Operation of waste repositories adds many billions more to the costs. The US government estimates that to build a high-level nuclear waste repository and operate it for 150 years would cost US$96.2 billion (in 2007 dollars) (A$143 billion), a 67% increase on the 2001 estimate.[199]

The South Australian Nuclear Fuel Royal Commission estimated a similar figure: A$145 billion over 120 years for construction, operation and decommissioning of a high-level nuclear waste repository.[200]

5.4 Fire and chemical explosion in the world's only deep underground nuclear waste repository

No operating 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."[201]

In a separate incident, on 14 February 2014, an explosion (resulting from a heat-generating chemical reaction) ruptured one of the barrels stored underground at WIPP. 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. WIPP was closed for three years. Direct and indirect costs associated with the accident are estimated at over US$2 billion (A$2.9 billion).[202]

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."[203]

A safety analysis conducted before WIPP opened predicted that one radiation release accident might occur every 200,000 years.[204] On the basis of real-world experience, i.e. empirical evidence, that estimate needs to be revised upwards to 10,000 radiation-release 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: "At the beginning, there was an almost fanatical attention to safety. I'm

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[199] World Nuclear Association, 6 Aug 2008, 'Yucca Mountain cost estimate rises to $96 billion', http://www.world-nuclear-news.org/WR-Yucca_Mountain_cost_estimate_rises_to_96_billion_dollars-0608085.html

[200] Nuclear Fuel Cycle Royal Commission Report, May 2016, http://yoursay.sa.gov.au/system/NFCRC_Final_Report_Web.pdf

[201] 6 June 2014, 'Fire and leaks at the world's only deep geological waste repository', Nuclear Monitor #787, www.wiseinternational.org/node/4245

[202] https://www.latimes.com/nation/la-na-new-mexico-nuclear-dump-20160819-snap-story.html

[203] 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

[204] 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

afraid the emphasis shifted to looking at how quickly and how inexpensively they could dispose of this waste."[205] 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."[206]

For more information on the WIPP accidents, see:

- Nuclear Monitor #801, 9 April 2015, 'One deep underground dump, one dud', https://www.wiseinternational.org/nuclear-monitor/801/one-deep-underground-dump-one-dud
- The Ecologist, 27 Nov 2014, 'New Mexico nuclear waste accident a 'horrific comedy of errors' that exposes deeper problems', https://theecologist.org/2014/nov/27/new-mexico-nuclear-waste-accident-horrific-comedy-errors-exposes-deeper-problems

5.5 Nuclear waste generated by small modular reactors and Generation IV reactors

Small modular reactors

Claims that small modular reactors (SMRs) based on conventional light-water reactor technology are advantageous with respect to nuclear waste have no logical or evidentiary basis.

The South Australian Nuclear Fuel Cycle Royal Commission said in its Final Report that "SMRs have lower thermal efficiency than large reactors, which generally translates to higher fuel consumption and spent fuel volumes over the life of a reactor."[207]

Likewise, a 2017 article by Princeton University researchers concludes: "Of the different major SMR designs under development, it seems none meets simultaneously the key challenges of costs, safety, waste, and proliferation facing nuclear power today and constraining its future growth. In most, if not all designs, it is likely that addressing one or more of these four problems will involve choices that make one or more of the other problems worse."[208]

One of the authors of the above-mentioned article, M.V. Ramana, notes in a different article that "a smaller reactor, at least the water-cooled reactors that are most likely to be built earliest, will produce more, not less, nuclear waste per unit of electricity they generate because of lower efficiencies."[209]

A 2016 European Commission document states:[210]
"At the current stage of development it cannot be assessed whether the decommissioning and waste management costs of SMRs will significantly differ from those of larger reactors. Due to the loss of

[205] 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
[206] ibid.
[207] http://yoursay.sa.gov.au/system/NFCRC_Final_Report_Web.pdf
[208] M.V. Ramana and Zia Mian, Jan 2017, 'Small Modular Reactors and the Challenges of Nuclear Power', https://www.aps.org/units/fps/newsletters/201701/reactors.cfm
[209] M.V. Ramana, 23 June 2018, 'The future of nuclear power in the US is bleak', http://thehill.com/opinion/energy-environment/393717-the-future-of-nuclear-power-in-the-us-is-bleak
[210] European Commission, 4 April 2016, 'Commission Staff Working Document, Accompanying the document: Communication from the Commission, Nuclear Illustrative Programme presented under Article 40 of the Euratom Treaty for, the opinion of the European Economic and Social Committee', https://ec.europa.eu/energy/sites/ener/files/documents/1_EN_autre_document_travail_service_part1_v10.pdf

economies of scale, the decommissioning and waste management unit costs of SMR will probably be higher than those of a large reactor (some analyses state that between two and three times higher)."

Generation IV concepts and nuclear waste

Lindsay Krall and Allison Macfarlane have written an important article in the *Bulletin of the Atomic Scientists* debunking claims that certain Generation IV reactor concepts promise major advantages with respect to nuclear waste management.[211] Krall is a post-doctoral fellow at the George Washington University. Macfarlane is a professor at the same university, a former chair of the US Nuclear Regulatory Commission from July 2012 to December 2014, and a member of the Blue Ribbon Commission on America's Nuclear Future from 2010 to 2012.

Krall and Macfarlane focus on molten salt reactors and sodium-cooled fast reactors, and draw on the experiences of the US Experimental Breeder Reactor II and the US Molten Salt Reactor Experiment.

The article abstract notes that Generation IV developers and advocates "are receiving substantial funding on the pretense that extraordinary waste management benefits can be reaped through adoption of these technologies" yet "molten salt reactors and sodium-cooled fast reactors – due to the unusual chemical compositions of their fuels – will actually exacerbate spent fuel storage and disposal issues."

Krall and Macfarlane further state:
"The core propositions of non-traditional reactor proponents – improved economics, proliferation resistance, safety margins, and waste management – should be re-evaluated. The metrics used to support the waste management claims – i.e. reduced actinide mass and total radiotoxicity beyond 300 years – are insufficient to critically assess the short- and long-term safety, economics, and proliferation resistance of the proposed fuel cycles.
"Furthermore, the promised (albeit irrelevant) actinide reductions are only attainable given exceptional technological requirements, including commercial-scale spent fuel treatment, reprocessing, and conditioning facilities. These will create low- and intermediate-level waste streams destined for geologic disposal, in addition to the intrinsic high-level fission product waste that will also require conditioning and disposal.
"Before construction of non-traditional reactors begins, the economic implications of the back end of these non-traditional fuel cycles must be analyzed in detail; disposal costs may be unpalatable. The reprocessing/treatment and conditioning of the spent fuel will entail costs, as will storage and transportation of the chemically reactive fuels. These are in addition to the cost of managing high-activity operational wastes, e.g. those originating from molten salt reactor filter systems. Finally, decommissioning the reactors and processing their chemically reactive coolants represents a substantial undertaking and another source of non-traditional waste. ...
"Finally, treatment of spent fuels from non-traditional reactors, which by Energy Department precedent is only feasible through their respective (re)processing technologies, raises concerns over proliferation and fissile material diversion. Pyroprocessing and fluoride volatility-reductive extraction systems optimized for spent fuel treatment can – through minor changes to the chemical conditions – also extract plutonium (or uranium 233 bred from thorium). Separation from lethal fission products would eliminate the radiological barriers protecting the fuel from intruders seeking to obtain and purify fissile

[211] Lindsay Krall and Allison Macfarlane, 2018, 'Burning waste or playing with fire? Waste management considerations for non-traditional reactors', Bulletin of the Atomic Scientists, 74:5, pp.326-334, https://tandfonline.com/doi/10.1080/00963402.2018.1507791

material. Accordingly, cost and risk assessments of predisposal spent fuel treatments must also account for proliferation safeguards.
"Radioactive waste cannot be "burned"; fission of actinides, the source of nuclear heat, inevitably generates fission products. Since some of these will be radiotoxic for thousands of years, these high-level wastes should be disposed of in stable waste forms and geologic repositories. But the waste estimates propagated by nuclear advocates account only for the bare mass of fission products, rather than that of the conditioned waste form and associated repository requirements.
"These estimates further assume that the efficiency of actinide fission will surge, but this actually relies on several rounds of recycling using immature reprocessing technologies. The low- and intermediate-level wastes that will be generated by these activities will also be destined for geologic disposal but have been neglected in the waste estimates. More important, reprocessing remains a security liability of dubious economic benefit, so the apparent need to adopt these technologies simply to prepare non-traditional spent fuels for storage and disposal is a major disadvantage relative to light water reactors. Theoretical burnups for fast and molten salt reactors are too low to justify the inflated back-end costs and risks, the latter of which may include a commercial path to proliferation.
"Reductions in spent fuel volume, longevity, and total radiotoxicity may be realized by breeding and burning fissile material in non-traditional reactors. But those relatively small reductions are of little value in repository planning, so utilization of these metrics is misleading to policy-makers and the general public. We urge policy-makers to critically assess non-traditional fuel cycles, including the feasibility of managing their unusual waste streams, any loopholes that could commit the American public to financing quasi-reprocessing operations, and the motivation to rapidly deploy these technologies."

Pyroprocessing: the integral fast reactor waste fiasco

In theory, integral fast reactors (IFRs) would consume nuclear waste and convert it into low-carbon electricity. In practice, the EBR-II (IFR) R&D program in Idaho has left a legacy of troublesome waste. This saga is detailed in a 2017 article[212] and a longer report[213] by the Union of Concerned Scientists' senior scientist Dr. Edwin Lyman, drawing on documents obtained under Freedom of Information legislation.

Lyman writes:[214]
"[P]yroprocessing has taken one potentially difficult form of nuclear waste and converted it into multiple challenging forms of nuclear waste. DOE has spent hundreds of millions of dollars only to magnify, rather than simplify, the waste problem. …
"The FOIA documents we obtained have revealed yet another DOE tale of vast sums of public money being wasted on an unproven technology that has fallen far short of the unrealistic projections that DOE used to sell the project …
"Everyone with an interest in pyroprocessing should reassess their views given the real-world problems experienced in implementing the technology over the last 20 years at INL. They should also note that the variant of the process being used to treat the EBR-II spent fuel is less complex than the process that would be needed to extract plutonium and other actinides to produce fresh fuel for fast reactors. In other words, the technology is a long way from being demonstrated as a practical approach for electricity production."

[212] Ed Lyman / Union of Concerned Scientists, 12 Aug 2017, 'The Pyroprocessing Files', http://allthingsnuclear.org/elyman/the-pyroprocessing-files
[213] Edwin Lyman, 2017, 'External Assessment of the U.S. Sodium-Bonded Spent Fuel Treatment Program', https://s3.amazonaws.com/ucs-documents/nuclear-power/Pyroprocessing/IAEA-CN-245-492%2Blyman%2Bfinal.pdf
[214] Ed Lyman / Union of Concerned Scientists, 12 Aug 2017, 'The Pyroprocessing Files', http://allthingsnuclear.org/elyman/the-pyroprocessing-files

5.6 Importing nuclear waste as a money-making venture and/or to fuel Generation IV reactors

The abandoned proposal for nuclear waste importation in SA

The 2015/16 SA Nuclear Fuel Cycle Royal Commission had a significant level of pro-nuclear bias[215] but nevertheless rejected most of the options it was asked to consider – uranium conversion and enrichment, nuclear fuel fabrication, conventional and Generation IV nuclear power reactors, and spent fuel reprocessing.

The Royal Commission did however recommend further consideration of a proposal to import vast amounts of nuclear waste (138,000 tonnes of high-level nuclear waste (spent nuclear fuel) and 390,000 cubic metres of intermediate-level waste) as a money-making venture. Following the Royal Commission, the government initiated a Citizens' Jury which voted strongly in opposition to the proposal.[216] The SA Liberal Party (then in Opposition, now in Government) announced its intention to campaign against the proposal. The Nick Xenophon Team also announced its opposition while the SA Greens had opposed the proposal from the start. Premier Jay Weatherill later said that the plan is "dead", there is "no foreseeable opportunity for this", and it is "not something that will be progressed by the Labor Party in Government".[217]

Thus the proposal has little or no political support in SA, and it never enjoyed public support. The statewide consultation process led by the government randomly surveyed over 6,000 South Australians and found 53% opposition to the proposal compared to 31% support.[218] A November 2016 poll commissioned by the *Sunday Mail* found 35% support for the nuclear dump plan among 1,298 respondents.

Opposition from Traditional Owners was overwhelming[219] and was a significant factor in the Citizen Jury's rejection of the proposal. The Jury's report said: "There is a lack of Aboriginal consent. We believe that the government should accept that the Elders have said NO and stop ignoring their opinions."[220]

While in office, Premier Weatherill said Traditional Owners should have a right of veto over any proposal to build nuclear waste storage or disposal facilities on their land – and he later wrote to then Prime Minister Turnbull suggesting that the same right of veto should apply to plans for a national radioactive waste facility in SA. The current federal plan is being contested in the courts and the Human Rights Commission by Traditional Owner representative groups for the two targeted regions.

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[215] 'A Critique of the South Australian Nuclear Fuel Cycle Royal Commission', Dec 2015, https://nuclear.foe.org.au/critique-of-the-sa-nuclear-fuel-cycle-royal-commission/
'Bias of SA Nuclear Royal Commission finally exposed', 4 Nov 2016, http://reneweconomy.com.au/bias-sa-nuclear-royal-commission-finally-exposed-57819/
'SA Nuclear Royal Commission Is A Snow Job', 29 April 2016, http://reneweconomy.com.au/sa-nuclear-royal-commission-is-a-snow-job-18368/

[216] Citizens' Jury report: http://assets.yoursay.sa.gov.au/production/2016/11/06/07/20/56/26b5d85c-5e33-48a9-8eea-4c860386024f/final%20jury%20report.pdf

[217] http://indaily.com.au/news/politics/2017/06/07/theres-no-foreseeable-opportunity-jay-declares-nuke-dump-dead/

[218] http://assets.yoursay.sa.gov.au/production/2016/11/11/09/37/34/0c1d5954-9f04-4e50-9d95-ca3bfb7d1227/NFCRC%20CARA%20Community%20Views%20Report.pdf

[219] https://www.anfa.org.au/wp-content/uploads/2016/10/Traditional-Owner-statements-SA-dump-Oct2016.pdf

[220] http://assets.yoursay.sa.gov.au/production/2016/11/06/07/20/56/26b5d85c-5e33-48a9-8eea-4c860386024f/final%20jury%20report.pdf

In October 2017, a cross-party SA Parliament Joint Committee on the Findings of the Nuclear Fuel Cycle Royal Commission released its report with just one recommendation: "That the South Australian Government should not commit any further public funds to pursuing the proposal to establish a repository for the storage of nuclear waste in South Australia."[221]

Importing high-level nuclear waste for recycle in fast reactors

The Committee will likely receive submissions arguing that Australia should import high-level nuclear waste which could be converted into fuel for 'integral fast reactors' (IFRs – discussed in Appendix 3 to the joint NGO submission to the federal nuclear inquiry[222]).

The SA Nuclear Fuel Cycle Royal Commission investigated such propositions and concluded:[223]
"[A]dvanced fast reactors and other innovative reactor designs are unlikely to be feasible or viable in the foreseeable future. The development of such a first-of-a-kind project in South Australia would have high commercial and technical risk. Although prototype and demonstration reactors are operating, there is no licensed, commercially proven design. Development to that point would require substantial capital investment. Moreover, electricity generated from such reactors has not been demonstrated to be cost competitive with current light water reactor designs."

Little has changed since the Royal Commission reported – except the collapse of a number of Generation IV R&D projects including Generation mPower, Transatomic Power, MidAmerican Energy's SMR plans, and TerraPower's plan for a demonstration fast reactor in China. Further, The UK government abandoned consideration of 'integral fast reactors' for plutonium disposition in March 2019 – and the US government did the same in 2015.

Creative accounting

The engineering of a positive economic case to proceed with the nuclear waste import plan was discussed by ABC journalist Stephen Long: "Would you believe me if I told you the report that the commission has solely relied on was co-authored by the president and vice president of an advocacy group for the development of international nuclear waste facilities?"[224]

Worse still, there was no peer review of the report that was co-authored by the president and vice president of an advocacy group for the development of international nuclear waste facilities.

Prof. Barbara Pocock, an economist at the University of South Australia, said: "All the economists who have replied to the analysis in that report have been critical of the fact that it is a 'one quote' situation. We haven't got a critical analysis, we haven't got a peer review of the analysis".[225]

The Royal Commission's economic claims were eventually subject to a peer review. The SA Parliament's Joint Committee commissioned a report by the Nuclear Economics Consulting Group which noted that the Royal Commission's economic analysis failed to consider important issues which "have significant serious potential to adversely impact the project and its commercial outcomes"; that assumptions about price were "overly optimistic" in which case "project profitability is seriously at risk"; that the

[221] http://www.parliament.sa.gov.au/Committees/Pages/Committees.aspx?CTId=2&CId=333
[222] https://www.aph.gov.au/DocumentStore.ashx?id=9eee9d5f-4362-4b30-b0b8-3b65ff98215f&subId=670271
[223] http://yoursay.sa.gov.au/system/NFCRC_Final_Report_Web.pdf
[224] http://www.abc.net.au/news/2016-11-08/should-south-australia-be-storing-nuclear-waste-above-ground/8003156
[225] http://www.abc.net.au/news/2016-11-03/radioactive-waste-dump-would-boost-sa-economy-commission-hears/7991170

25% cost contingency for delays and blowouts was likely to be a significant underestimate; and that the assumption the project would capture 50% of the available market had "little support or justification".[226]

South Australian economist Prof. Richard Blandy from Adelaide University, said: "The forecast profitability of the proposed nuclear dump rests on highly optimistic assumptions. Such a dump could easily lose money instead of being a bonanza."[227]

Likewise, a detailed report by the Australia Institute concluded that the business case for a nuclear waste storage facility in South Australia was exaggerated, that the project would be risky, and that an economic loss was well within the range of possible outcomes.[228]

Further information on the abandoned proposal for nuclear waste importation to SA

Submission to the SA Parliament's Joint Select Committee by Friends of the Earth, Conservation SA and Australian Conservation Foundation, July 2016, https://nuclear.foe.org.au/wp-content/uploads/SA-Joint-Select-Cttee-FoE-ACF-CCSA-final.pdf

5.7 Transportation of nuclear waste

Transport incidents and accidents are commonplace

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) involving all forms of radioactive and nuclear materials, including waste.[229] Of the 38 incidents in the UK in 2011 alone, 11 involved irradiated nuclear fuel flasks (up from eight in 2010). One of those 11 events involved a low-impact collision.[230]

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[226] http://nuclear-economics.com/wp-content/uploads/2016/11/2016-11-11-NECG-Review-of-Jacobs-MCM-Report-for-SA-Parliament.pdf

[227] http://www.abc.net.au/news/2016-11-03/radioactive-waste-dump-would-boost-sa-economy-commission-hears/7991170

See also Prof. Blandy's submission to the Royal Commission: http://nuclearrc.sa.gov.au/app/uploads/2016/04/Blandy-Richard.pdf

See also https://indaily.com.au/news/business/analysis/2016/06/07/how-a-high-level-nuclear-waste-dump-could-lose-money/

[228] https://www.tai.org.au/content/digging-answers or direct download: https://www.tai.org.au/sites/default/files/P222A%20Digging%20for%20answers%20-%20SA%20Nuclear%20Royal%20Commission%20Submission%20FINAL.pdf

[229] 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/

See also 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/

[230] 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/

In a report on 806 recorded radioactive transport incidents in the UK from 1958−2004, Hughes et al. found that 111 involved 'residues inc. discharged INF flasks', 101 involved irradiated fuel, and 63 involved (other) radioactive wastes:[231]

MATERIAL TYPE *Source: Hughes et al, 2006*	**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

There were 187 incidents during the shipment of irradiated nuclear fuel flasks from 1958−2004[232] – 23% of the total number of 806 recorded incidents. There is no evidence of safety improvements in the UK:

- In 2008, 18% of recorded incidents (7/39) involved irradiated nuclear fuel flasks.[233]
- In 2009, 24% of recorded incidents (8/33) involved irradiated nuclear fuel flasks.[234]
- In 2010, 27% of recorded incidents (8/30) involved irradiated nuclear fuel flasks.[235]
- In 2011, 29% of recorded incidents (11/38) involved irradiated nuclear fuel flasks.[236]

Transport incidents are also commonplace in France and presumably a comparable percentage involve nuclear wastes. In 2008, the French nuclear safety agency IRSN produced a report summarising radioactive transport accidents and incidents from 1999−2007.[237] The IRSN manages a database listing reported deviations, anomalies, incidents and accidents (known generically as "events") relating to transport. The database lists 901 events from 1999−2007 − on average 100 events annually or about two each week.

[231] 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

[232] 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

[233] 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/

[234] ibid.

[235] 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/

[236] 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/

[237] IRSN (France), 21 Oct 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

In the US, in the eight years from 2005 to 2012, 72 incidents involving trucks carrying radioactive material on highways caused US$2.4 million in damage and one death, according to the Transportation Department's Pipeline and Hazardous Materials Safety Administration.[238]

Costs of accidents

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 "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.[239]

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.[240]

Direct and indirect costs associated with the Feb. 2014 chemical explosion underground at the Waste Isolation Plant in New Mexico are estimated at over US$2 billion (A$2.9 billion).[241]

European nuclear waste transport scandal

In the late 1990s, a whistleblower supplied WISE-Paris, an environmental and energy NGO, with information which sparked a major controversy over frequent excessive radioactive contamination of waste containers, rail cars, and trucks.[242] 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:[243]
"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

[238] 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
[239] 7 July 2000, www.state.nv.us/nucwaste/news2000/nn10719.htm
[240] www.nuclearfiles.org/menu/timeline/timeline_page.php?year=2004
[241] https://www.latimes.com/nation/la-na-new-mexico-nuclear-dump-20160819-snap-story.html
[242] 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
[243] www.wise-paris.org/index.html?/english/ournewsletter/6_7/editorial.html&/english/frame/menu.html
and
http://www.wise-paris.org/index.html?/english/ournewsletter/6_7/page4.html&/english/frame/menu.html&/english/frame/band.html

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."

French Environment Minister Dominique Voynet said:[244]
"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."

Some examples of accidents and incidents

Some examples of accidents and incidents involving the transport of radioactive waste are noted here:

In early 1998, it was revealed that "airtight" spent fuel storage canisters at ANSTO's Lucas Heights site had been infiltrated by water − 90 litres in one case − and corrosion had resulted. 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).[245]

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.[246] ANSTO provides no further detail but presumably some of the accidents and incidents involve waste materials.

In October 2014, a ship carrying radioactive waste which was set adrift in the North Sea after it caught fire led to 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

[244] http://www.wise-paris.org/english/ournewsletter/6_7/no6_7.pdf
[245] Sutherland Shire Environment Centre:
https://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
[246] ANSTO, 2003, Submission to NSW Parliament's 'Joint Select Committee into the Transportation and Storage of Nuclear Waste'

assist. The cargo was reportedly undamaged. The waste was from the Dounreay experimental nuclear power plant.[247] 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."[248]

On 5 February 2014, a truck hauling salt caught fire at the Waste Isolation Pilot Plant (WIPP) in New Mexico. 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."[249]

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 in the UK. The train is used to take spent nuclear fuel to Sellafield but, as it was returning to Cheshire, was empty.[250]

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 microsieverts.[251]

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.[252]

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[247] 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
[248] Herald, 30 July 2014 www.heraldscotland.com/news/home-news/plans-for-radioactive-waste-by-sea-are-criticised.24898732
[249] 6 June 2014, 'Fire and leaks at the world's only deep geological waste repository', Nuclear Monitor #787, www.wiseinternational.org/node/4245
[250] 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
[251] International Panel on Fissile Materials, 21 Jan 2014, http://fissilematerials.org/blog/2014/01/nuclear_train_accident_in.html
[252] AP, 9 Sept 2002, 'WIPP truck runs off highway in Wyoming', http://lubbockonline.com/stories/090902/upd_075-3941.shtml

A serious incident occurred in the UK in 2002.[253] 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.

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 was 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.[254]

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.[255]

<u>More information on transport incidents and accidents</u>

Section 8.5 in this submission: 'Nuclear transport security issues'.

Section 3.8 in the August 2015 joint submission to the SA Nuclear Fuel Cycle Royal Commission by Friends of the Earth Australia, the Australian Conservation Foundation, and Conservation SA.[256]

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[253] 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
[254] WISE News Communique #467, February 28, 1997
Die Tageszeitung (FRG) February 5, 1997
Greenpeace press release February 4, 1997
[255] Legislative Research Service Paper, Parliamentary Library, Canberra
[256] https://nuclear.foe.org.au/wp-content/uploads/NFCRC-submission-FoEA-ACF-CCSA-FINAL-AUGUST-2015.pdf

'Responsibility overboard: the shocking record of the company shipping nuclear waste to Australia', Natalie Wasley, 14 Aug 2018, Online Opinion, http://www.onlineopinion.com.au/view.asp?article=19892&page=0

5.8 Report of the 2004 NSW Joint Select Committee on the Transportation and Storage of Nuclear Waste

The Recommendations of the 2004 NSW Joint Select Committee on the Transportation and Storage of Nuclear Waste are reproduced below.[257] They raise numerous issues that remain unresolved today.

Particular attention is drawn to Recommendation 22 which states that, if the federal government failed to adopt the Committee's recommendations 1 to 4 (and indeed those recommendations were largely ignored by the federal government), 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)."

The current inquiry of the NSW Standing Committee on State Development should consider making similar recommendations to provide some protection against any federal government attempt to impose a national nuclear waste repository in NSW.

Such a move would provide a level of state legislative assurance and recourse comparable to that which exits in other jurisdictions including Queensland, Victoria, WA, SA and the Northern Territory.

The Recommendations of the 2004 Joint Select Committee were as follows:

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;

[257] NSW Joint Select Committee on the Transportation and Storage of Nuclear Waste, February 2004, Report No. 53/01, www.parliament.nsw.gov.au/nuclearwaste or https://www.parliament.nsw.gov.au/committees/listofcommittees/Pages/committee-details.aspx?pk=214

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)

6. HEALTH AND SAFETY

Please see the relevant sections in the joint submission to the SA Nuclear Fuel Cycle Royal Commission by Friends of the Earth Australia, the Australian Conservation Foundation, and Conservation SA:[258]

Section 1.8:

Public and worker health hazards
Radiation and health
Radon
Leukemia
Uranium, radiation and health
Olympic Dam whistleblower
Polonium exposure at Olympic Dam
Uranium companies promote radiation junk science
Case study: the Chernobyl death toll

Section 1.11: Past uranium industry practices, including the exposure of children to radiation at disused uranium mines and processing plants in Australia.
Section 3.9 Lessons from accidents such as Fukushima
Section 3.10 Regulation
Section 3.13:

Health and safety
History of accidents
Safety challenges
Safety of nuclear vs renewables
Probabilistic risk assessments
Attacks on nuclear plants
Childhood leukemias near nuclear power stations
Australia's track record
Counterfeit, fraudulent and suspect items

Since the joint submission for the Royal Commission was written, further evidence has emerged about the systemic corruption in South Korea's nuclear industry. This is important because South Korea would be one of the few potential suppliers of reactor technology to Australia (and it would be the preferred supplier in the view of the Australian Nuclear Association). For more information please see Appendix 1 in the joint NGO submission to the federal nuclear inquiry.[259]

The Committee will likely receive submissions stating or implying that there is a threshold below which exposure to ionising radiation is harmless. Such views are at odds with expert scientific opinion, including:

- 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."[260]
- 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

[258] https://nuclear.foe.org.au/wp-content/uploads/NFCRC-submission-FoEA-ACF-CCSA-FINAL-AUGUST-2015.pdf
[259] https://www.aph.gov.au/DocumentStore.ashx?id=9eee9d5f-4362-4b30-b0b8-3b65ff98215f&subId=670271
[260] 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

without a threshold and … the smallest dose has the potential to cause a small increase in risk to humans."[261]

Whether the relationship between radiation dose and health effects is linear at low doses is more contentious, but there is significant scientific support for a linear no-threshold (LNT) model, e.g. 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 cancer risks from intermediate to very low doses currently appears to be the most appropriate methodology."[262]

While there is (and always will be) uncertainty with LNT at low doses and dose rates, it is important 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[263] 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."

Death toll from the Chernobyl and Fukushima disasters

Claims that the Chernobyl death toll was <100 have no basis in scientific evidence. 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.[264] The estimated death toll rises further when populations beyond those three countries are included. For example, a study by Cardis et al. published in the *International Journal of Cancer* estimates 16,000 deaths.[265]

Likewise, claims that exposure to ionising radiation from the Fukushima disaster will not result in cancer deaths have no basis in scientific evidence. The World Health Organization 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

[261] 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
[262] 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
[263] 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
[264] 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/
[265] 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

thyroid cancer among females exposed as infants, an increased risk of up to 70% (from a 0.75% lifetime risk up to 1.25%).[266]

Inadequate regulation

The Fukushima disaster resulted from grossly inadequate safety and regulatory standards in Japan's nuclear industry. Standards improved somewhat in the aftermath of the disaster but the collusive practices of Japan's 'nuclear village' are returning.[267] In other words, if lessons were learnt from the disaster, they are already being forgotten. This repeats the situation that followed the Chernobyl disaster − stronger safety and regulatory standards for a time, followed by complacency, cost-cutting, and governments ceding to industry calls to lower safety standards.

Inadequate regulation is evident in numerous countries with which Australia has uranium supply and nuclear cooperation agreements, e.g. China[268], India[269], Russia[270], the US[271], Japan[272], South Korea[273], and Ukraine.[274]

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

[267] Nuclear Monitor #800, 19 March 2015, 'Japan's 'nuclear village' reasserting control', www.wiseinternational.org/nuclear-monitor/800/japans-nuclear-village-reasserting-control

[268] Emma Graham-Harrison, 25 May 2015, 'China warned over 'insane' plans for new nuclear power plants', https://www.theguardian.com/world/2015/may/25/china-nuclear-power-plants-expansion-he-zuoxiu

[269] A. Gopalakrishnan, 13 Nov 2017, 'India Should Halt Further Expansion of its Nuclear Power Program', The Citizen, https://www.thecitizen.in/index.php/en/NewsDetail/index/2/12239/India-Should-Halt-Further-Expansion-of-its-Nuclear-Power-Program

[270] Vladimir Slivyak, 2014, 'Russian Nuclear Industry Overview', https://ecdru.files.wordpress.com/2017/04/russian-nuc-ind-overviewrgb.pdf

[271] Edwin Lyman, 29 Aug 2019, 'Aging nuclear plants, industry cost-cutting, and reduced safety oversight: a dangerous mix', https://thebulletin.org/2019/08/aging-nuclear-plants-industry-cost-cutting-and-reduced-safety-oversight-a-dangerous-mix/
Gregory Jaczko, 17 May 2019, 'I Oversaw the US Nuclear Power Industry. Now I Think It Should Be Banned', https://www.commondreams.org/views/2019/05/17/i-oversaw-us-nuclear-power-industry-now-i-think-it-should-be-banned

[272] Nuclear Monitor #800, 19 March 2015, 'Japan's 'nuclear village' reasserting control', www.wiseinternational.org/nuclear-monitor/800/japans-nuclear-village-reasserting-control

[273] Nuclear Monitor #844, 25 May 2017, 'South Korea's 'nuclear mafia'', www.wiseinternational.org/nuclear-monitor/844/south-koreas-nuclear-mafia

[274] L. Todd Wood, 30 March 2017, 'Ukrainian corruption casts nuclear pall over Europe', http://www.washingtontimes.com/news/2017/mar/30/ukrainian-corruption-casts-nuclear-pall-over-all-e/
Nuclear Monitor #832, 19 Oct 2016, 'Ukraine's nuclear power program going from bad to worse', https://www.wiseinternational.org/nuclear-monitor/832/ukraines-nuclear-power-program-going-bad-worse

7. COMMUNITY ENGAGEMENT

The introduction of nuclear power would require bipartisan support at the federal level – and bipartisan support in the relevant state/territory – over a period of five or more election cycles.

Currently there is a bipartisan political consensus that Australia should not introduce nuclear power and that federal legal prohibitions should be retained. A number of states including NSW have legislation banning nuclear power.

The last time one of the major parties promoted nuclear power was in the mid-2000s when Prime Minister John Howard and some other members of the Coalition government promoted nuclear power. During the 2007 election campaign, at least 22 Coalition candidates publicly distanced themselves from the government's pro-nuclear power policy. The pro-nuclear power policy was seen to be a liability and it was abandoned immediately after the election by the Coalition.

The current promotion of nuclear power by a small number of Coalition MPs has once again generated division. The Queensland state Liberal National Party made a submission[275] to the current federal nuclear inquiry arguing for the retention of federal legislation banning nuclear power and that "Australia's rich renewable energy sources are more affordable and bring less risk than the elevated cost and risk associated with nuclear energy". The submission further states: "We would encourage the Committee to ensure an increased emphasis is placed on measures designed to encourage investment in renewable energy that creates green jobs and lowers electricity bills, both for consumers and industry, which does not include nuclear energy."

Public support for nuclear power in Australia has varied significantly over the past decade according to opinion polls. Part of the variation could be explained by polling questions, sample sizes etc. Some poll results are as follows:

- 2019: 44% support for nuclear power, 40% opposition.[276] (51% believe nuclear power would help lower power prices, 26% disagree.)
- 2019: 45% support, 40% opposition[277] (rising to 51% support if the question was preceded by this rather loaded statement: 'If the worries about carbon dioxide are a real problem, many suggest that the cleanest energy source Australia can use is nuclear power.')
- 2015: 26.6% support for nuclear power in South Australia (level of opposition not surveyed).[278]
- 2013: 30% support for nuclear power, 53% opposition.[279]
- 2011 (after the Fukushima disaster): 34% support for nuclear power, 61% opposition (Roy Morgan poll).

As noted above, support rose 6% in a 2019 poll when the question was preceded by the dubious assertion that 'many suggest that the cleanest energy source Australia can use is nuclear power'. Unsurprisingly, opposition rises when questions about nuclear power mention radioactive waste or the risk of serious accidents. As the Issues Paper notes, in a 2012 poll 63% agreed that nuclear power isn't

[275] https://www.aph.gov.au/DocumentStore.ashx?id=5c2cf4df-5ef7-420c-86f3-eee32033fa3f&subId=669992

[276] https://www.theguardian.com/australia-news/2019/jun/18/australians-support-for-nuclear-plants-rising-but-most-dont-want-to-live-near-one

[277] http://www.roymorgan.com/findings/8144-nuclear-power-in-australia-september-2019-201910070349

[278] 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

[279] John McAneney et al., 14 Oct 2013, 'Why don't Australians see nuclear as a climate change solution?', http://theconversation.com/why-dont-australians-see-nuclear-as-a-climate-change-solution-19099

worth it because of the need to manage radioactive waste, and 62% agreed that nuclear power is too risky because of the risk of serious accidents.[280]

Opposition to a locally-built nuclear power plant is clear:

- 2019: 28% "would be comfortable living close to a nuclear power plant", 60% would not.
- 2019: 19% would agree to a nuclear power plant being built in their area, 58% would be opposed and a further 23% would be "anxious" (so 81% would be opposed or anxious).[281]
- 2011: 12% of Australians would support a nuclear plant being built in their local area, 73% would oppose it. (Morgan poll)
- 2006: 10% Australians would strongly support a nuclear plant being built in their local area, 55% would strongly oppose it. (Newspoll)

Opinion polls clearly show that renewables are far more popular than nuclear power:

- A 2019 survey of 1,960 Australians aged 18 years and older found that only 22% included nuclear power in their top three preferences, behind solar 76%, wind 58%, hydro 39% and power storage 29%.[282] Further, 59% of respondents put nuclear power in their bottom three preferences.[283]
- 2015: An IPSOS poll found support among Australians for solar power (78–87%) and wind power (72%) is far higher than support for coal (23%) and nuclear (26%).[284]
- 2015: When given the option of eight energy sources, 84% included solar in their top three, 69% included wind, 21% included gas and only 13% included nuclear.[285]
- 2013: Expanding the use of renewable energy sources (71%) was the most popular option to tackle climate change, followed by energy-efficient technologies (58%) and behavioural change (54%), with nuclear power (17.4%) a distant fourth.[286]

Regarding community engagement, nuclear lobbyists would need to convince Australians to accept the "non-negligible" risk of a catastrophic accident, to use the words of Dr. Ziggy Switkowski at the 29 August 2019 hearing of the federal nuclear inquiry.[287] Australians would need to be persuaded that a solution exists for nuclear waste management even though no country in the world has an operating repository for high-level nuclear waste, and the deep underground repository for intermediate-level waste in the US was shut for three years after safety and regulatory lapses resulted in a chemical explosion and the closure of the repository for three years.

Australians would also need to be persuaded that nuclear power makes sense in this country even though it clearly does not. Peter Farley, a fellow of the Australian Institution of Engineers, offered this comparison in January 2019:[288]

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[280] NSW Parliamentary Research Service, Sept 2019, 'Uranium Mining and Nuclear Energy in New South Wales', https://www.parliament.nsw.gov.au/researchpapers/Pages/Uranium-Mining-and-Nuclear-Energy-in-New-South-Wales.aspx

[281] http://www.roymorgan.com/findings/8144-nuclear-power-in-australia-september-2019-201910070349

[282] Australia Institute, Sept 2019, 'Climate of the Nation 2019 Tracking Australia's attitudes towards climate change and energy', https://www.tai.org.au/sites/default/files/Climate%20of%20the%20Nation%202019%20%5BWEB%5D.pdf

[283] Katharine Murphy, 10 Sept 2019, 'Australians increasingly fear climate change-related drought and extinctions' https://www.theguardian.com/environment/2019/sep/10/australians-increasingly-fear-climate-change-related-drought-and-extinctions

[284] http://www.ipsos.com.au/Ipsos_docs/Solar-Report_2015/Ipsos-ARENA_SolarReport.pdf

[285] http://www.solarquotes.com.au/blog/climate-institute-poll-finds-australians-support-renewables/

[286] John McAneney et al., 14 Oct 2013, 'Why don't Australians see nuclear as a climate change solution?', http://theconversation.com/why-dont-australians-see-nuclear-as-a-climate-change-solution-19099

[287] www.aph.gov.au/Parliamentary_Business/Committees/House/Environment_and_Energy/Nuclearenergy/Public_Hearings

[288] https://reneweconomy.com.au/how-did-wind-and-solar-perform-in-the-recent-heat-wave-40479/

"As for nuclear the 2,200 MW Plant Vogtle is costing US$25 billion plus financing costs, insurance and long term waste storage. ... For the full cost of US$30 billion, we could build 7,000 MW of wind, 7,000 MW of tracking solar, 10,000 MW of rooftop solar, 5,000MW of pumped hydro and 5,000 MW of batteries. ... That is why nuclear is irrelevant in Australia. It has nothing to do with greenies, it's just about cost and reliability."

8. SECURITY IMPLICATIONS

Security risks associated with civil nuclear programs include the following:

- military strikes by nation-states on nuclear sites (primarily to prevent their use in weapons programs);
- attacks on or theft from nuclear facilities (or transport vehicles) by individuals or sub-national groups;
- nuclear theft and smuggling;
- sabotage / insider threats (e.g. the sabotage incident at Sellafield in 2000[289]).

8.1 Military strikes on nuclear plants

Historical examples of (conventional) 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 i) shutting down their power reactors or ii) taking the risk of attacks potentially leading to widespread, large-scale dispersal of radioactive materials. Shutting down reactors would reduce risks but vulnerabilities would remain including reactor cores, waste stores and reprocessing plants (in those countries with reprocessing programs).

Nuclear physicist Richard Garwin poses these questions:[290]
"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."

8.2 Nuclear theft and smuggling

The IAEA summarises problems associated with nuclear theft, smuggling and other such illicit activities:[291]
"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

[289] 27 March 2000, 'Sabotage inquiry at Sellafield under way', www.irishtimes.com/news/sabotage-inquiry-at-sellafield-under-way-1.260139
[290] Richard L. Garwin, 2001, 'Can the World Do Without Nuclear Power?', www.solarpeace.ch/solarpeace/Download/20010409_Garwin_NuclearPowerArticle.pdf
[291] www-ns.iaea.org/security/itdb.asp

a total of 1337 cases involving other unauthorized activities, including the unauthorized disposal of radioactive materials or discovery of uncontrolled sources."

8.3 Insider threats

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.[292] One example they cite was the apparent insider sabotage of a diesel generator at the San Onofre nuclear plant in the United States in 2012. Another example 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 incidents 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)
#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

8.4 Nuclear weapons proliferation

The weapons proliferation risks associated with civil nuclear programs are well understood and there is a long history of nation-states using civil nuclear programs as cover for weapons programs – five of the ten countries that have produced nuclear weapons did so under cover of a civil program, and power reactors have been used to produce plutonium for weapons in most or all of the other five nation-states (the 'declared' nuclear weapons states).[293]

The (civil) nuclear industry and its lobbyists have a long history of denying the connections between civil programs (including nuclear power programs) and weapons proliferation. However there has been a dramatic shift in recent years with a growing number of industry bodies and lobbyists acknowledging and even celebrating nuclear power–weapons connections.[294] They argue that weapons programs will be adversely affected unless further subsidies are made available to troubled nuclear power programs that make important contributions to weapons programs (personnel, materials, etc.).

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[292] 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, https://www.amacad.org/publication/worst-practices-guide-insider-threats-lessons-past-mistakes

[293] Nuclear Monitor #804, 28 May 2015, 'The myth of the peaceful atom', https://www.wiseinternational.org/nuclear-monitor/804/myth-peaceful-atom

[294] Andy Stirling and Phil Johnstone, 23 Oct 2018, ', A global picture of industrial interdependencies between civil and military nuclear infrastructures', Nuclear Monitor #868, https://www.wiseinternational.org/nuclear-monitor/868/global-picture-industrial-interdependencies-between-civil-and-military-nuclear

To give one example of this dramatic transformation, Michael Shellenberger from 'Environmental Progress', a pro-nuclear lobby group in the US, used to deny nuclear power–weapons connections, even claiming that "nuclear energy prevents the spread of nuclear weapons".[295] However in 2018 Shellenberger stated that "national security, having a weapons option, is often the most important factor in a state pursuing peaceful nuclear energy".

An analysis by Environmental Progress found that of the 26 nations that are building or are committed to build nuclear power plants, 23 have nuclear weapons, had weapons, or have shown interest in acquiring weapons.[296] "While those 23 nations clearly have motives other than national security for pursuing nuclear energy," Shellenberger wrote, "gaining weapons latency appears to be the difference-maker."[297]

Shellenberger also pointed to research[298] which found that 31 nations had the capacity to enrich uranium or reprocess plutonium, and that 71% of them created that capacity to give themselves weapons latency.

Shellenberger noted that "at least 20 nations sought nuclear power at least in part to give themselves the option of creating a nuclear weapon" – Argentina, Australia, Brazil, Egypt, France, Italy, India, Iran, Iraq, Israel, Japan, Libya, Norway, Romania, South Africa, Sweden, Switzerland, Taiwan, West Germany, Yugoslavia.[299]

Proliferation concerns would be lessened if the international safeguards system was rigorous and properly funded. Sadly it is neither, as discussed in section 11.1 of this submission.

8.5 Nuclear transport security issues

Hirsch et al. summarise some of the security risks associated with the transport of nuclear materials:[300]
"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)

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[295] Nuclear Monitor #865, 6 Sept 2018, 'Nuclear lobbyist Michael Shellenberger learns to love the bomb, goes down a rabbit hole', https://www.wiseinternational.org/nuclear-monitor/865/nuclear-lobbyist-michael-shellenberger-learns-love-bomb-goes-down-rabbit-hole

[296] Environmental Progress, 2018, Nations Building Nuclear – Proliferation Analysis, https://docs.google.com/spreadsheets/d/1YA4gLOekXNXiwpggCEx3uUpeu_STBlN_gHD60B5QG1E/edit#gid=0

[297] Michael Shellenberger, 29 Aug 2018, 'For Nations Seeking Nuclear Energy, The Option To Build A Weapon Remains A Feature Not A Bug', https://www.forbes.com/sites/michaelshellenberger/2018/08/29/for-nations-seeking-nuclear-energy-the-option-to-build-a-weapon-remains-a-feature-not-a-bug/

[298] Matthew Fuhrmann and Benjamin Tkach, 8 Jan 2015, 'Almost nuclear: Introducing the Nuclear Latency dataset', Conflict Management and Peace Science, https://doi.org/10.1177/0738894214559672 http://journals.sagepub.com/doi/abs/10.1177/0738894214559672

[299] Michael Shellenberger, 29 Aug 2018, 'For Nations Seeking Nuclear Energy, The Option To Build A Weapon Remains A Feature Not A Bug', https://www.forbes.com/sites/michaelshellenberger/2018/08/29/for-nations-seeking-nuclear-energy-the-option-to-build-a-weapon-remains-a-feature-not-a-bug/

[300] 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, https://www.researchgate.net/publication/262630918

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, 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."

Nuclear transport security issues are discussed in greater detail in section 4.10 (pp.243–250) of the joint submission to the SA Nuclear Fuel Cycle Royal Commission by Friends of the Earth Australia, the Australian Conservation Foundation, and Conservation SA.[301]

8.6 Australian nuclear security issues

Security incidents at ANSTO's Lucas Heights site in southern Sydney include the following[302]:

- 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."[303]

[301] https://nuclear.foe.org.au/wp-content/uploads/NFCRC-submission-FoEA-ACF-CCSA-FINAL-AUGUST-2015.pdf
[302] Tilman Ruff, 2006, 'Nuclear Terrorism', EnergyScience Coalition Briefing Paper #10, www.energyscience.org.au/FS10%20Nuclear%20Terrorism.pdf
[303] 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.[304]

Nuclear engineers Alan Parkinson and John Large have warned that Australia's proposed national radioactive waste facility 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).

A number of problems with Australia's approach to nuclear security issues 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

[304] 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

9. THE URANIUM MINING AND EXPORT INDUSTRY

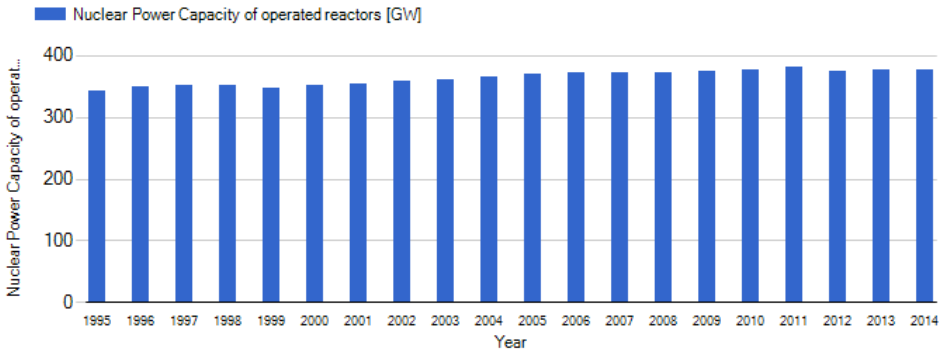
9.1 The global status and trajectory of nuclear power

From the mid-2000s until the 2011 Fukushima disaster, there was a strong increase in the number of nuclear power reactor starts – 50 construction starts from 2006–2010 compared to just 13 in the preceding five years.[305] Some of that momentum spilled over in the post-Fukushima years (32 construction starts from 2011–2015) but construction starts have dried up dramatically (14 from Jan. 2016 to Sept. 2019).

In January 2019, the World Nuclear Association expected that 15 power reactors would enter commercial operation this year.[306] But as of early October, the number was just four.[307]

That pattern has been repeated in recent years: delays have been the norm and estimated dates for grid-connection have been pushed back.

In broad terms, this pattern probably means that the previous spike in construction starts probably won't result in a spike (or even a mini-spike) in operational reactors. Instead, for the next decade or so, there will probably be a continuation of the stagnation that has been evident for the past quarter-century.[308]



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

Beyond the next decade, the Era of Nuclear Decommissioning[309] is likely to set in, characterised by a decline of global nuclear power capacity and growing difficulties (including financial difficulties) with waste management and decommissioning. International Energy Agency chief economist Fatih Birol said in 2014: "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."[310]

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[305] *IAEA, 2018, 'Nuclear Power Reactors in the World', https://www-pub.iaea.org/books/IAEABooks/13379/Nuclear-Power-Reactors-in-the-World*

[306] *World Nuclear Association, January 2019, 'Plans For New Reactors Worldwide', www.world-nuclear.org/information-library/current-and-future-generation/plans-for-new-reactors-worldwide.aspx*

[307] *IAEA, Power Reactor Information System, https://pris.iaea.org/PRIS/, accessed 11 Oct 2019.*

[308] *https://pris.iaea.org/PRIS/WorldStatistics/WorldTrendNuclearPowerCapacity.aspx*

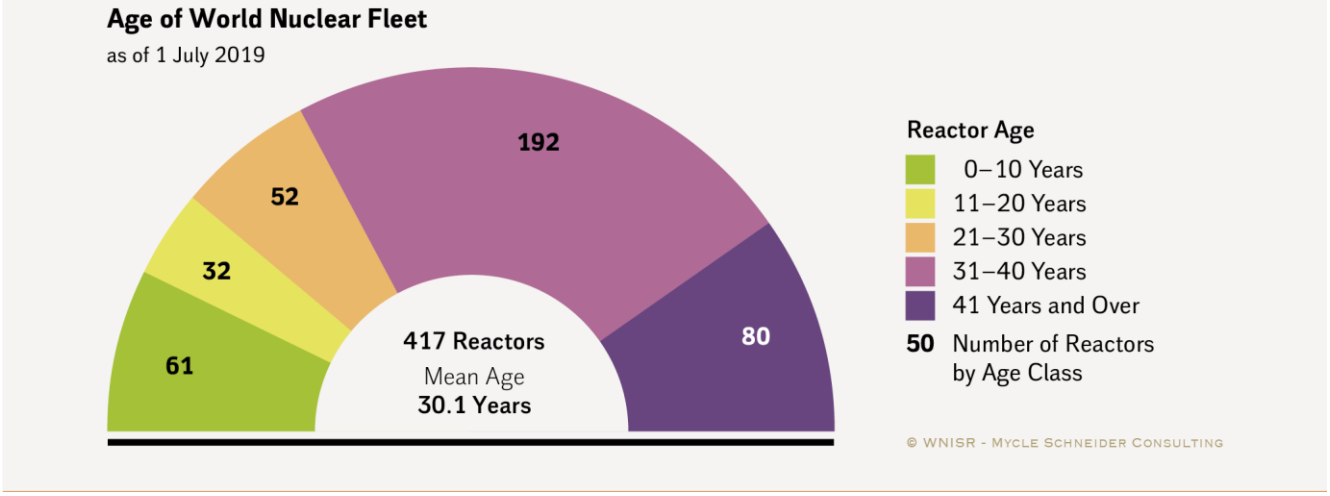
[309] *Nuclear Monitor #856, 29 Jan 2018, '2017 in Review: Nuclear Power', https://www.wiseinternational.org/nuclear-monitor/856/2017-review-nuclear-power*

[310] World Nuclear News, 12 Nov 2014, 'Nuclear industry shares IEA concern', www.world-nuclear-news.org/NP-Nuclear-industry-shares-IEA-concern-12111401.html

Power reactor construction starts in recent years have averaged only around four per year but there will likely be an average of 8-11 permanent reactor shut-downs annually over the next few decades:

- The International Energy Agency expects a "wave of retirements of ageing nuclear reactors" and an "unprecedented rate of decommissioning" – almost 200 reactor shut-downs between 2014 and 2040.[311]
- The International Atomic Energy Agency (IAEA) anticipates 320 GW of retirements from 2017 to 2050.[312]
- Another IAEA report estimates up to 139 GW of permanent shut-downs from 2018–2030 and up to 186 GW of further shut-downs from 2030-2050.[313]

Figure 14 | Age Distribution of Operating Reactors in the World



Source: World Nuclear Industry Status Report 2019.[314]

The industry will attempt to bridge the gap between construction starts and shut-downs by increasing construction starts and by deferring permanent reactor shut-downs. But its efforts will most likely only slow rather than stop what seems an inevitable decline.

The ageing of the reactor fleet is the elephant in the room. The average age of the fleet has just passed 30 years.[315] Shut-downs can be deferred (at some cost, and at some risk) but they cannot be deferred indefinitely. As noted above, the International Atomic Energy Agency (IAEA) anticipates 320–325 gigawatts (GW) of retirements by 2050 – that is more than 80% of current world capacity.[316]

Nuclear's share of electricity generation peaked at 17.6% in 1996 and now stands at just over 10%.

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[311] International Energy Agency, 2014, 'World Energy Outlook 2014 Factsheet', www.iea.org/media/news/2014/press/141112_WEO_FactSheet_Nuclear.pdf

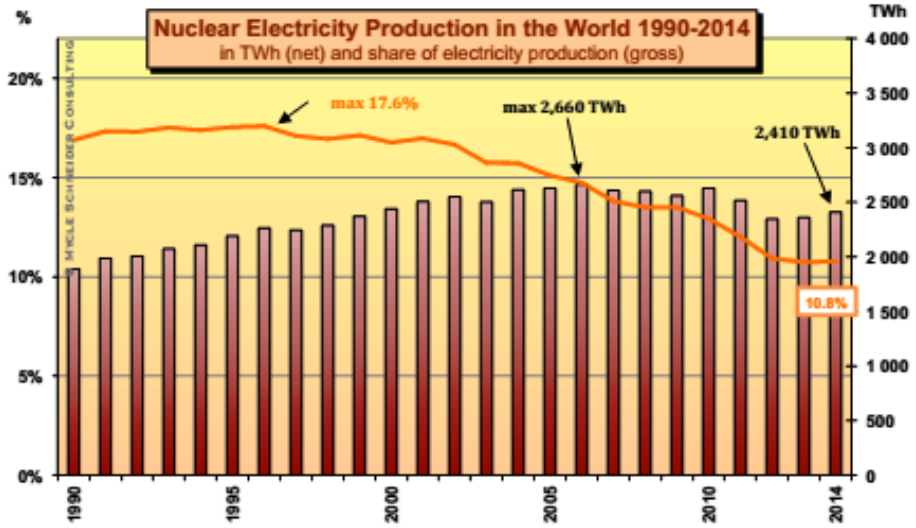
[312] International Atomic Energy Agency, 28 July 2017, 'International Status and Prospects for Nuclear Power 2017: Report by the Director General', www.iaea.org/About/Policy/GC/GC61/GC61InfDocuments/English/gc61inf-8_en.pdf

[313] International Atomic Energy Agency, 2018, 'Energy, Electricity and Nuclear Power Estimates for the Period up to 2050: 2018 Edition', https://www-pub.iaea.org/MTCD/Publications/PDF/RDS-1-38_web.pdf

[314] Mycle Schneider and Antony Froggatt, Sept 2019, 'World Nuclear Industry Status Report 2019', https://www.worldnuclearreport.org/WNISR2019-Assesses-Climate-Change-and-the-Nuclear-Power-Option.html

[315] *Mycle Schneider and Antony Froggatt, Sept 2019, 'World Nuclear Industry Status Report 2019', https://www.worldnuclearreport.org/WNISR2019-Assesses-Climate-Change-and-the-Nuclear-Power-Option.html*

[316] *International Atomic Energy Agency, 2018, 'Energy, Electricity and Nuclear Power Estimates for the Period up to 2050: 2018 Edition', https://www-pub.iaea.org/MTCD/Publications/PDF/RDS-1-38_web.pdf*



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

The likelihood of a decline of global nuclear power capacity is a view being expressed by a growing number of 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."[317]

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[318] – 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[319] – 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).[320]

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.[321] That would have required completion of the 62 reactors then under construction, and start-to-finish construction of another 204 reactors with an average rate of almost 13 start-ups per year (whereas the average number of construction starts since 2016 has been about four per year).

9.2 The global uranium industry in the context of nuclear power stagnation and looming decline

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

[317] 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/
[318] http://fissilematerials.org/library/rr08.pdf
[319] http://trustandverify.wordpress.com/2010/10/01/428/
[320] www-pub.iaea.org/mtcd/publications/pdf/pub1304_web.pdf
[321] 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

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.[322]

Energy consultants Julian Steyn and Thomas Meade wrote in *Nuclear Engineering International* in October 2014:[323]
"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."

Likewise, investment strategist Christopher Ecclestone from Hallgarten & Company wrote in November 2014:[324]
"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."

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.[325]

Likewise, 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 predicted "a long period of relatively low prices, in which uranium producers will find it hard to make a living".[326] Kidd stated 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 stated, 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."[327]

Very little has changed since the above opinions were expressed in 2014. The uranium price has fallen further still.[328]

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[322] 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
[323] Julian Steyn and Thomas Meade, 1 Oct 2014, 'Uranium market doldrums continue', www.neimagazine.com/features/featureuranium-market-doldrums-continue-4390747/
[324] http://investorintel.com/nuclear-energy-intel/nexgen-energy-nxe-v-survivor-nuclear-winter/
[325] 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
[326] www.neimagazine.com/opinion/opinionthe-future-of-uranium-higher-prices-to-come-4259437/
[327] www.neimagazine.com/opinion/opinionthe-future-of-uranium-higher-prices-to-come-4259437/
[328] https://www.cameco.com/invest/markets/uranium-price

Uranium Prices (US$ / pound uranium oxide)

	1 June 2007	1 Dec. 2008	1 Feb. 2011	1 Dec. 2011	1 Dec. 2014	1 Dec. 2017
Spot price	136	52.50	69.63	51.88	35.50	22.32
Long-term contract price	95	70	71.50	62	49.50	30.67
Notes	Peak bubble	Bubble burst	Pre-Fukushima	Decline 2011-16	Decline 2011-16	Flat

Source: Cameco: www.cameco.com/invest/markets/uranium-price

The only fundamental change over the past five years is that numerous mines have been put into care-and-maintenance[329], such that production and demand are more closely matched and production is no longer increasing the already massive global glut of uranium.

Uranium mine production increased by 50% from 2007 to 2016.[330] The increase was driven, initially at least, by expectations of the nuclear renaissance that didn't eventuate. Mine production plus secondary sources have consistently exceeded demand – 2017 was the eleventh consecutive year of surplus according to the CEO of uranium company Bannerman Resources.[331] "We have to recognise that we over-produce, and we are responsible for this fall in the price," said Areva executive Jacques Peythieu in 2017.[332]

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.[333] 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.[334] Macquarie believes that China has enough uranium stockpiled to meet demand for about seven years at forecast 2020 consumption rates.

Japan is estimated to have stockpiles of around 100 million pounds of uranium oxide.[335] 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.[336] 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.

[329] https://wiseinternational.org/nuclear-monitor/857/2017-review-uranium-best-left-ground

[330] World Nuclear Association, 'World Uranium Mining Production, Updated July 2017, www.world-nuclear.org/information-library/nuclear-fuel-cycle/mining-of-uranium/world-uranium-mining-production.aspx

[331] World Nuclear Association, 7 Dec 2017, 'Uranium suppliers respond to production cuts', www.world-nuclear-news.org/UF-Uranium-suppliers-respond-to-production-cuts-0712177.html

[332] World Nuclear Association, 2 May 2017, 'Uranium producers prepare for market recovery', www.world-nuclear-news.org/UF-Uranium-producers-prepare-for-market-recovery-02051701ST.html

[333] 29 March 2014, 'Conjuring Profits from Uranium's Resurgence: Interview with David Sadowski', http://theenergycollective.com/streetwiser/360291/conjuring-profits-uraniums-resurgence-david-sadowski

[334] Rhiannon Hoyle, 17 Jan 2015, 'Uranium Rally Running Low on Juice', http://online.barrons.com/articles/uranium-rally-running-low-on-juice-1421462807

[335] http://seekingalpha.com/article/2822326-charting-uraniums-gain-brent-cook-looks-for-sweet-spots-in-the-athabasca-basin

[336] www.businessspectator.com.au/article/2015/2/13/energy-markets/japan-plans-post-fukushima-nuclear-restart

9.3 Australia's uranium industry

Uranium is produced in around 20 countries. Australia accounts for approximately 11% of global production, compared to Australia's 2002−2011 average of 18.2%.[337]

The uranium industry generates less than 0.2% of national export revenue (0.19% in 2013/14[338]) and accounts for less than 0.02% of jobs in Australia.[339]

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 of Australia's uranium reserves. Plans for an open-pit mega-expansion of Olympic Dam were abandoned in 2012.

9.4 Implausible uranium industry growth estimates

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

The Australian Uranium Association frequently 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[340] or 5896 t U3O8).

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

- In a 2012 paper[341], 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 October 2019.

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[342]:

- 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).

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

[338] 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

[339] 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

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

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

[342] 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

- 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[343]).

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.[344]

Inflated projections from the Commonwealth Department of Industry, Innovation and Science are presented in the Issues Paper prepared for this NSW inquiry. Figure 30 on the 'potential growth' of Australia's uranium industry envisages a period of stagnation followed by five new mines opening from the late-2020s onwards. That scenario is deeply implausible.

Uranium has made a negligible contribution to Australia's export revenue and employment. Decline is more likely than growth. Indeed uranium mining has ceased at Ranger in the NT, and the processing of stockpiled ore will cease in the next few years. South Australia will then be the only state involved in mining uranium (at Olympic Dam and Beverley Four Mile).

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

[344] 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

10. URANIUM – ENVIRONMENTAL POLLUTION

In addition to the comments below, please also see relevant sections in the joint submission to the SA Nuclear Fuel Cycle Royal Commission by Friends of the Earth Australia, the Australian Conservation Foundation, and Conservation SA:[345]

- Sections 1.10 and 1.11 (p.60ff) on the environmental impacts of the uranium mining industry.
- Section 2 (p.88–89) on depleted uranium waste.
- Section 2 (p.101–102) on spent nuclear fuel reprocessing.
- Section 3.11 (p.167ff) on greenhouse emissions.
- Section 3.11 (p.173–174) on nuclear winter.
- Section 3.11 (p.174–176) on climate change and nuclear hazards (nuclear power plants are vulnerable to threats which are being exacerbated by climate change).

Please also see section 5 in this submission regarding nuclear waste management, transport and storage.

10.1 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.

A 2003 report by the Senate References and Legislation Committee found "a pattern of under-performance and non-compliance" in the uranium mining industry.[346] 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".

10.2 Olympic Dam

Environmental spills at Olympic Dam[347] range from the trivial to the spectacular leak of around 5 million cubic metres of tailings liquid in the early to mid-1990s.[348]

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

[345] https://nuclear.foe.org.au/wp-content/uploads/NFCRC-submission-FoEA-ACF-CCSA-FINAL-AUGUST-2015.pdf

[346] 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

[347] 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: http://archive.foe.org.au/anti-nuclear/issues/oz/u/roxby/incidents

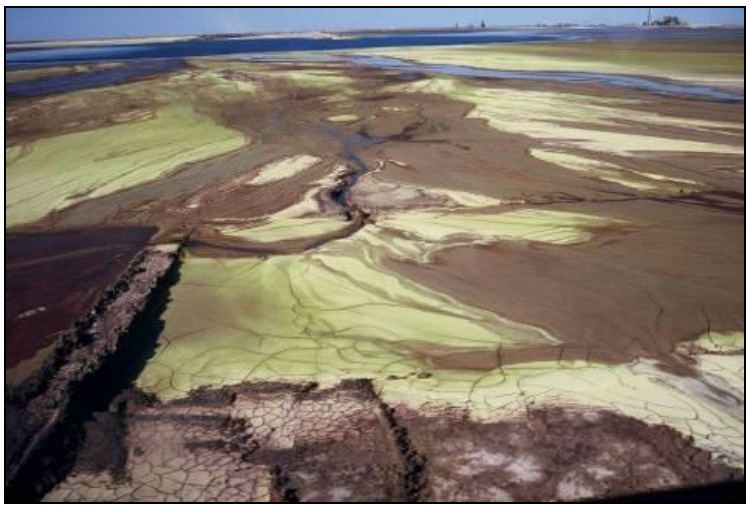
[348] http://archive.foe.org.au/anti-nuclear/issues/oz/u/roxby/leak1994

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.[349]

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.[350]

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.[351] 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."[352] Yet the Liberal Party did not oppose or try to improve the Labor government's Bill.

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.[353]



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

[349] *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
[350] Michelle Wiese Bockmann, 10 March 2006, 'Waste fears at uranium mine', *The Australian*.
[351] 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: https://nuclear.foe.org.au/roxby-downs-indenture-act/
[352] 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
[353] 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

Tailings and rehabilitation costs: Tailings are stored above ground at Roxby Downs. The tailings dump currently amounts to well over 150 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."[354] 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."

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[355] and the Royal Commission is well placed to shed light on this controversy.

Next planned expansion of Olympic Dam: Independent researcher David Noonan has raised numerous concerns about the planned expansion of Olympic Dam. His research is posted at https://nuclear.foe.org.au/olympic-dam. In particular, we encourage the Committee and the Secretariat to read Mr. Noonan's briefing papers on the planned expansion:[356]

- BHP Legal Privileges in the Olympic Dam Indenture Act 1982 Override SA Laws
- BHP Seek a Toxic Tailings Expansion Without a Full Safety Risk Assessment
- Preconditions to Protect Mound Springs in Olympic Dam Expansion EIS Guidelines
- BHP Uranium Mining Triggers "Protection Of The Environment" Under the EPBC Act
- BHP Must Lodge a Bond to Cover 100% of Rehabilitation Liabilities at Olympic Dam
- Migratory Birds at Risk of Mortality if BHP Continues Use of Evaporation Ponds
- The Need to Assess a Feasible Alternative: No-Uranium Sales from Olympic Dam

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.[357] 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.

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

[355] 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: http://archive.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", http://archive.foe.org.au/sites/default/files/Keane%20Mound%20Springs%2097.pdf

[356] https://nuclear.foe.org.au/olympic-dam/

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

Mr Parnell's speech[358] 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*
> *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*

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

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 world's 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.

10.3 Yeelirrie

Yeelirrie is part of the Seven Sisters dreaming and has many important cultural sites which are under threat from the proposed uranium project. The community has fought against the proposed mine for over 40 years and neighbouring pastoralists have joined the fight in recent years.

On the July 4, 2017 the Conservation Council of WA (CCWA) and members of the Tjiwarl Native Title group, represented by the Environmental Defender's Office WA (EDO), commenced legal proceedings in the Supreme Court of Western Australia for a review of the decision by the former Minister for Environment, Albert Jacob to approve the Yeelirrie Uranium Project in the last days of the Barnett Government.

The project by Canadian uranium company Cameco would involve a 9 km open mine pit and processing plant in the Midwest, clearing 2,421 hectares of native vegetation and generating 36 million tonnes of radioactive mine waste to be stored in open pits.

Environmental approval for the project was eventually granted by previous WA Environment Minister Albert Jacob against the recommendation of the Environmental Protection Authority (EPA) which advised that there was an unacceptable risk that the project would lead to the extinction of several unique species of subterranean fauna.

Further, despite a clear commitment to the contrary the former federal Environment Minister Melissa Price approved the project in highly politicised circumstances the day before the 2019 federal election was called.

The approvals exemplify a flawed approach to environmental approvals.

10.4 In-situ leach uranium mines – dumping contaminated liquid in groundwater

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).

A 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.[359]

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:[360]
"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

[359] 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
http://minerals.dmitre.sa.gov.au/__data/assets/pdf_file/0018/20547/honeymoon_reporting.pdf

[360] 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.

mined aquifer. The injected liquid is acidic (pH 1.8 to 2.8) and contains heavy metals and radionuclides originating from the orebody."

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, academic hydrogeologist Assoc. Prof. Gavin Mudd states:[361]
"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:[362]
"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.

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[361] https://nuclear.foe.org.au/in-situ-leach-uranium-mining/
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
[362] https://nuclear.foe.org.au/in-situ-leach-uranium-mining/

"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 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:[363]
"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 stated 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."

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

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 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.

The 7 January 2009 *Beverley Four Mile Project Public Environment Report and Mining Lease Proposal* document (p.7.9, table 7.6) stated that there is a 'Moderate' risk of contamination preventing a return to pastoral use.

10.5 Failure to properly rehabilitate closed uranium mines

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)[364]:

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*

[364] 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

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.*

***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.

See also Assoc. Prof. Mudd's submission to the current federal nuclear inquiry.[365]

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 of uranium mines.

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.

[365] https://www.aph.gov.au/DocumentStore.ashx?id=f56bb200-edcc-463c-9bd7-06357450c133&subId=670300

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:[366]

- 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.
- 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.

10.6 Ranger rehabilitation concerns

A recent report has found Australia's largest national park is at long-term risk unless the clean-up of the Ranger uranium mine in Kakadu is done comprehensively and effectively.[367] *Unfinished business,* co-authored by the Sydney Environment Institute (SEI) at the University of Sydney and the Australian Conservation Foundation (ACF), identifies significant data deficiencies, a lack of clarity around regulatory and governance frameworks and uncertainty over the adequacy of current and future financing – especially in relation to future monitoring and mitigation works for the controversial mine site.

Mine operator Energy Resources of Australia (ERA) and parent company Rio Tinto are required to clean up the site to a standard suitable for inclusion in the surrounding Kakadu National Park, dual-listed on UNESCO's World Heritage list. No mine in the world has ever successfully achieved this standard of clean up.

Report co-author Dr Rebecca Lawrence from SEI said: "Rehabilitating what is essentially a toxic waste dump is no easy task. Rio Tinto faces a complex and costly rehabilitation job. The challenge is not to simply scrape rocks into holes and plant trees, it is to make sure mine tailings, radioactive slurry and

[366] For more information and references see the relevant entries at www.australianmap.net
[367] https://www.acf.org.au/unfinished_business_rehabilitating_ranger

toxic by-products of mining are isolated from the surrounding environment for 10,000 years. To ensure this in a monsoonal environment, such as Kakadu, which is already being impacted by climate change, raises enormous environmental and governance challenges. For the rehabilitation process to even have a chance at success, the existing opaque and complex regulatory regime needs an urgent overhaul."

Tailings, the waste material remaining after the processing of finely ground ore, are one of the serious environmental risks outlined in the report. The report examines how ERA and Rio Tinto intend to deliver on the federal government's requirement to protect the Kakadu environment by isolating any tailings and making sure contaminants do not result in any detrimental environmental impacts for at least 10,000 years.

Dave Sweeney from ACF said: "Long after the miners have gone this waste remains a direct human and environmental challenge," said report co-author. This issue is key to the long-term health of Kakadu but there is insufficient evidence and detail on how this work will be managed and assured in the future. Without this detail there will be a sleeping toxic time bomb deep inside Kakadu. At its London AGM Rio again committed to make sure ERA has the financial resources to deliver its rehabilitation obligations, however the financial mechanism to do so remains undisclosed. The community and environment of Kakadu need certainty and a comprehensive clean up. This work is a key test of the commitment and capacity of Northern Territory and Commonwealth regulators as well as the mining companies."

The report makes recommendations to improve the chances of a successful clean-up at Ranger. It calls for increased transparency, public release of key project documents, a better alignment of research and operations and open review processes for key decision points.

10.7 Uranium exploration in the Arkaroola Wilderness Sanctuary – a serious failure of government oversight/regulation

In November 2013, Marathon Resources gave up on the uranium sector, stating that the "risks were more likely to exceed rewards".[368] 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.[369]

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[370]:

- 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[371]; and
- the failure to follow safety procedures resulting in loss of wildlife.

[368] AAP, 21 Nov 2013, 'Explorer says uranium project unviable', www.heraldsun.com.au/business/breaking-news/explorer-says-uranium-project-unviable/story-fni0xqe4-1226765298924
[369] http://australianmap.net/mt-gee/
[370] http://australianmap.net/mt-gee/
[371] http://unknownsa.blogspot.com.au/2008/09/case-of-missing-minerals.html

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.

10.8 Regulation of uranium mining in South Australia

The Issues Paper written by the NSW Parliamentary Research Service presents a very generous assessment of uranium regulation in SA.[372]

The Issues Paper states that the 2015/16 SA Nuclear Fuel Cycle Royal Commission "found that current regulatory practices in SA have been informed by the mistakes of the past." In support of that statement, the Issues Paper (and the Royal Commission) cites the problems with the Radium Hill uranium mine. The mine was closed in 1961 but, as the Issues Paper notes, proper rehabilitation has still not been carried out. What lessons have been learned from that experience? The Issues Paper provides no answer. Surely the failure to properly rehabilitate a uranium mine 50 years after its closure is a reason to

- belatedly rehabilitate the mine); and
- maintain the NSW prohibition against uranium mining (and to strengthen it by prohibiting uranium prospecting/exploration) given the clear, acknowledged failures of uranium regulation and rehabilitation at Radium Hill (and elsewhere – see section 10.5 in this submission).

Likewise, the Issues Paper cites the Port Pirie uranium processing plant. As with Radium Hill, the Port Pirie site has not been properly rehabilitated even though it was closed over 50 years ago. No evidence is provided that any lessons have been learned. No plans are in train to properly rehabilitate the Port Pirie site.

The Issues paper outlines the regulatory process in SA – but it ignores many failures including the following:

- Port Pirie.
- Radium Hill – ongoing tailings leaks, plus a radioactive waste repository that "is not engineered to a standard consistent with current internationally accepted practice" according to a 2003 SA government audit.[373]
- Olympic Dam (indefensible exemptions from environmental and other laws; failure to respond appropriately to revelations of leaks in the 'armoury' of the tailings 'retention' system; multiple 'extreme risk' status Tailings Storage Facilities; and other serious problems outlined in section 10.2 of this submission.)
- SA regulators failed to detect Marathon Resource's illegal dumping of low-level radioactive waste in the Arkaroola Wilderness Sanctuary. If not for the detective work of the managers of the Sanctuary, the illegal activities would never have been detected. The incident represents a serious failure of SA government regulation.

[372] NSW Parliamentary Research Service, Sept 2019, 'Uranium Mining and Nuclear Energy in New South Wales', https://www.parliament.nsw.gov.au/researchpapers/Pages/Uranium-Mining-and-Nuclear-Energy-in-New-South-Wales.aspx

[373] See section 3.2 (p.11) in the joint submission to the SA Nuclear Fuel Cycle Royal Commission, https://nuclear.foe.org.au/wp-content/uploads/NFCRC-submission-FoEA-ACF-CCSA-FINAL-AUGUST-2015.pdf

11. URANIUM – SAFEGUARDS AND WEAPONS PROLIFERATION

11.1 The limitations of safeguards

There are many problems and limitations with the international safeguards system. In articles and speeches during his tenure as IAEA Director General from 1997− 2009, Dr. Mohamed El Baradei said 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. Dr. 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."[374] 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.

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."[375] 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.

[374] 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
[375] IAEA, 1993, Against the Spread of Nuclear Weapons: IAEA Safeguards in the 1990s.

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 Committee on Treaties (JSCT) recommended in 2008 that "the Australian Government lobbies the IAEA and the five declared nuclear weapons states under the NPT to make the safeguarding of all conversion facilities mandatory."[376] However the Australian Government rejected the recommendation in its 2009 response to the JSCT report.[377]

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.

11.2 Australia's 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."[378]

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.

Australia has nuclear cooperation (uranium export) agreements with:

- 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).
- countries refusing to sign or ratify the UN Treaty on the Prohibition of Nuclear Weapons.

11.3 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

[376] 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

[377] Australian Government, 2009, 'Government Response to Report 94 of the Joint Standing Committee on Treaties: Australia-Russia Nuclear Cooperation Agreement'

[378] John Carlson, 1998, http://web.archive.org/web/20040217071924/http://www.aph.gov.au/hansard/joint/commttee/j2022.pdf, p.15

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.

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.[379] 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?"[380]

Japan's plutonium stockpiling and reprocessing plans continue to cause regional concern − for example China has recently voiced concern.[381] 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

[379] http://web.archive.org/web/20081114064230/http://archive.greenpeace.org/pressreleases/nuctrans/1999sep1.html
[380] http://web.archive.org/web/20081114064230/http://archive.greenpeace.org/pressreleases/nuctrans/1999sep1.html
[381] 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

permit transfers and reprocessing of AONM and could therefore put an end to the stockpiling of Australian-obligated plutonium.

11.4 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 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."[382]

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.

11.5 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 examples 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 Joint Standing Committee on Treaties recommended that: "Further consideration is given to the justification for secrecy of Material Unaccounted For'."[383] There is no legitimate justification for the secrecy surrounding MUF. ASNO has done no better than to cite commercial confidentiality.[384] 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.

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[382] 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.

[383] 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

[384] www.aph.gov.au/parliamentary_business/committees/house_of_representatives_committees?url=jsct/14may2008/subs/sub22_1.pdf

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."[385]

11.6 The Australian Safeguards and Non-Proliferation Office (ASNO)

A 2007 EnergyScience Coalition paper detailed many problems with ASNO. The paper concluded:[386]

"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 Joint Standing Committee on Treaties regarding safeguards in Russia, e.g. ASNO's defence of the indefensible Australia−India Nuclear Cooperation Agreement.

11.7 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.

[385] 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

[386] 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

- 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.

11.8 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."[387] 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.[388]

An enthusiast of integral fast reactors (IFR) claims they "cannot be used to generate weapons-grade material."[389] But IFRs can be used to produce plutonium for weapons.[390] 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."[391]

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.

[387] Tim Dean, 16 March 2011, 'The greener nuclear alternative', www.abc.net.au/unleashed/45178.html
[388] 'Thor-bores and uro-sceptics: thorium's friendly fire', Nuclear Monitor #801, 9 April 2015, www.wiseinternational.org/nuclear-monitor/801/thor-bores-and-uro-sceptics-thoriums-friendly-fire
[389] Barry Brook, 9 June 2009, 'An inconvenient solution', The Australian, http://bravenewclimate.com/2009/06/11/an-inconvenient-solution/
[390] Friends of the Earth, Australia, 'Nuclear Weapons and 'Generation 4' Reactors', https://nuclear.foe.org.au/nuclear-weapons-and-generation-4-reactors/
[391] George Stanford, 18 Sep 2010, 'IFR FaD 7 – Q&A on Integral Fast Reactors', http://bravenewclimate.com/2010/09/18/ifr-fad-7/

Fusion illustrates how difficult it is to disentangle the peaceful atom from 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."[392]

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."[393]

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".[394]

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.

[392] Khidhir Hamza, Sep/Oct 1998, 'Inside Saddam's Secret Nuclear Program', *Bulletin of the Atomic Scientists*, Vol. 54, No. 5.
[393] UK Royal Society, 13 Oct 2011, 'Fuel cycle stewardship in a nuclear renaissance', http://royalsociety.org/policy/projects/nuclear-non-proliferation/report
[394] John Carlson, 2009, 'Introduction to the Concept of Proliferation Resistance', www.foe.org.au/sites/default/files/Carlson%20ASNO%20ICNND%20Prolif%20Resistance.doc or http://archive.foe.org.au/sites/default/files/Carlson%20ASNO%20ICNND%20Prolif%20Resistance.doc