Submission to the House Select Committee on Nuclear Energy

Inquiry into Nuclear Power Generation in Australia

November 2024

Friends of the Earth Australia
Australian Conservation Foundation
Greenpeace Australia Pacific
The Wilderness Society
Climate Action Network Australia
Nature Conservation Council (NSW)
Environment Victoria
Conservation SA
Queensland Conservation Council
Conservation Council of WA
Environment Centre NT
Solutions for Climate Australia
Arid Lands Environment Centre
Environment Tasmania
Environs Kimberley
Cairns and Far North Environment Centre

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EXECUTIVE SUMMARY

Our groups maintain that federal and state legal prohibitions against the construction of nuclear power reactors have served Australia well. We strongly support the retention of these prudent, long-standing protections.

Claims that nuclear reactors could be generating electricity in Australia by 2035–37 do not withstand scrutiny. Introducing nuclear power to Australia would necessitate at least 10 years for licensing approvals and project planning, and around 10 years for reactor construction. Nuclear power reactors could only begin operating around the mid-2040s *at the earliest*. Most or all of Australia's remaining coal power plants will be closed long before nuclear reactors could begin supplying electricity.

Small modular reactors (SMRs) do not exist. The so-called operating SMRs in Russia and China were not built using serial factory production methods. They could not even be called prototype SMRs since there are no plans to mass-produce these reactor types using serial factory production methods. SMRs are best thought of as Smoke & Mirror Reactors: they do not exist. A few small reactors are under construction (in China, Russia and Argentina) but once again serial factory production methods are not being deployed.

Construction timelines for the so-called SMRs in Russia and China were protracted: 9 years in China and 12 years in Russia. In both countries, planning plus construction took 20 years or more.

After costs rose to a staggering A$31 billion per gigawatt, US company NuScale abandoned its flagship SMR project in Idaho last year. This led the Australian Coalition parties to abandon their SMR-only nuclear policy. Worse was to follow. In mid-2024, French utility EDF announced that it had suspended development of its Nuward SMR and reoriented the project "to a design based on proven technological building blocks." In May 2023, Ultra Safe Nuclear claimed at an Australian Senate hearing that the company is building SMRs in North America. In fact, the company has not begun building SMRs anywhere and in October 2024 the company announced that is pursuing a sale process under Chapter 11 of the US Bankruptcy Code.

Many other SMR projects have failed. The French government abandoned the planned ASTRID demonstration fast reactor in 2019; Babcock & Wilcox abandoned its Generation mPower SMR project in the US in 2017; Transatomic Power gave up on its molten salt reactor R&D in 2018; MidAmerican Energy gave up on its plans for SMRs in Iowa in 2013; TerraPower abandoned its plan for a prototype fast neutron reactor in China in 2018; and the US and UK governments abandoned consideration of 'integral fast reactors' for plutonium disposition in 2015 and 2019, respectively.

The SMR sector is littered with failed and abandoned projects, false claims and false dawns.

Large reactor construction projects have also suffered catastrophic cost overruns and delays. In both of Australia's AUKUS partner countries, early cost estimates were proven to be wrong by an order of magnitude:
* One project in the US was abandoned in 2017 after A$13.9 billion was wasted on the failed project, in South Carolina. Another project – the twin-reactor Vogtle project in the state of Georgia – reached completion at a cost 12 times higher than early estimates, and 6–7 years behind schedule. Not a single reactor is currently under construction in the US. Not one.
* In the UK, the Hinkley Point twin-reactor project was meant to be complete in 2017 but construction didn't even begin until 2018 and the latest cost estimate is 11.5 times higher than early estimates. No other reactors are under construction in the UK. The UK National Audit Office estimates that taxpayer subsidies for the Hinkley Point project could amount to £30 billion (A$58.4 billion). The Hinkley Point reactors are being built by French utility EDF. France's only recent domestic reactor construction project has also been a disaster: the reactor is still not operating 17 years after construction began and costs increased six-fold to A$31 billion.

If we were to make the heroic assumption – the absurd assumption – that reactor construction projects in Australia would fare as well (or as badly) as those in the US and the UK despite Australia's lack of experience and expertise, they would be 20+ year projects and costs would range from A$23.8 – 27.9 billion per gigawatt. Or A$31 billion per gigawatt for unproven NuScale SMR technology.

The two most significant economic modelling studies of Australia's energy options are the Net Zero Australia 2023 analysis and CSIRO's annual GenCost analyses. Both make extremely generous assumptions about nuclear costs – indeed both assume costs several times lower than real-world experience in the UK and the US – yet nuclear power is still found to be uneconomic in both studies.

Pursuing the nuclear path would be a recipe for increased power bills, increased taxes and increased greenhouse emissions. And it would pose unnecessary risks of catastrophic accidents and produce high-level nuclear waste for future generations of Australians to manage for millennia.

There are currently no operating deep underground repositories for high-level nuclear waste anywhere in the world. The one operating deep underground repository for long-lived intermediate-level nuclear waste − the Waste Isolation Pilot Plant in the US state of New Mexico – suffered a chemical explosion in a waste barrel in 2014 due to inept management and inadequate regulation.

Efforts to establish national radioactive waste facilities (repositories and stores) in Australia for low- and intermediate-level waste have repeatedly failed since the 1990s. Decades of failure do not inspire confidence that far more complex high-level nuclear waste challenges from a nuclear power program would be responsibly managed in Australia.

Claims that converting coal power plants to nuclear plants will be straightforward and advantageous rest on untested assumptions rather than real-world success stories. Coal-to-

nuclear transitions could potentially reduce nuclear costs by using some existing infrastructure but nuclear power would still be far more expensive than firmed renewables (i.e. renewable systems with storage capacity). No coal power plants have been repurposed as nuclear plants in the US or the UK, so purported synergies and cost savings are speculative.

There is no social license to introduce nuclear power to Australia. The Coalition's nuclear power policy is not supported by state governments in the five states being considered. There is little or no support from Coalition parties in those states. The nuclear policy is not supported by the energy industry, including the owners of the sites being targeted for nuclear reactors. The policy is not supported by scientists. It is not supported by the public – nuclear power recently regained its status as Australian's least popular energy source – or by First Nations communities. The Coalition's nuclear policy does not even enjoy widespread support within the Coalition: deep rifts are evident.

While nuclear power has been stagnant for more than 20 years, renewable energy is growing strongly around the world. Last year, nuclear power capacity fell by 1.7 gigawatts while renewable additions amounted to 507 gigawatts – record growth for the 22nd consecutive year. This year, the same pattern is repeating: nuclear stagnation and record renewables growth. Nuclear power accounts for a declining share of global electricity generation – currently 9.1%, barely half its historic peak – whereas the renewables share has grown to 30.2%. The International Energy Agency expects turbocharged growth in the coming years with renewables reaching 46% by 2030. Renewable energy sources currently generate over three times more electricity than nuclear reactors, and will likely generate five times more by the end of the decade.

The energy transition is well underway in Australia, with renewables supplying nearly 40% of the National Electricity Market. Nuclear power has no place in this transition. As Australia's leading scientific organisation CSIRO says, nuclear power "does not provide an economically competitive solution in Australia" and "won't be able to make a meaningful contribution to achieving net zero emissions by 2050."

1. DEPLOYMENT TIMEFRAMES

1.1 Large reactors

Claims that nuclear reactors could be generating electricity in Australia "within a decade"[1] or "by the mid-2030s"[2] do not withstand scrutiny.

Introducing nuclear power to Australia would necessitate:
* At least 10 years for: licensing approvals; a tender process and vendor selection; complex discussions and negotiations over funding and insurance arrangements; establishing a regulatory system; site selection, purchase and infrastructure development; establishing and maintaining a social license to operate; recruiting and training thousands of workers for reactor construction, operation and maintenance; recruiting and training hundreds of staff for regulation; an environmental impact assessment process including complex, lengthy assessments regarding seismic risks, water sourcing, etc.; removing a network of state and federal legal and policy bans and advancing agreements between Commonwealth and State/Territory jurisdictions; waste management planning; establishing nuclear safeguards arrangements; dealing with any legal challenges; etc.;
* Around 10 years for construction – probably more. (The 2024 edition of the World Nuclear Industry Status Report states: "Eleven countries completed 67 reactors over the decade 2014-2023 – of which 37 in China alone – with an average construction time of 9.9 years."[3] Excluding China, the average is over 10 years (see Table 3, p.61 in the Status Report). For nuclear 'newcomer' countries, as would be the case in Australia, a longer than average construction time could be expected.)
* An estimated 6.5 years of reactor operation to repay the energy and carbon debts from construction (the range of this 'energy payback time' is 5.6–14.1 years for conventional light-water reactors according to a University of Sydney study prepared for the Department of Prime Minister and Cabinet).[4]

Thus, even if federal and state legal prohibitions were repealed in the near future, a nuclear power reactor could only begin operating around the mid-2040s *at the earliest* and nuclear power could not make a change to greenhouse emissions reductions until mid-century *at the earliest*.

[1] https://www.skynews.com.au/australia-news/politics/were-not-starting-from-scratch-shadow-energy-minister-ted-obrien-flags-australia-could-have-nuclear-power-within-a-decade/news-story/5ff39390e7ba3271146620eec04f5cb9
[2] https://www.theage.com.au/politics/federal/cracks-appear-in-dutton-s-nuclear-plans-as-more-details-emerge-about-cheap-power-offer-20240619-p5jn54.html
[3] https://www.worldnuclearreport.org/World-Nuclear-Industry-Status-Report-2024
[4] http://pandora.nla.gov.au/pan/66043/20061201-0000/www.dpmc.gov.au/umpner/docs/commissioned/ISA_report.pdf

Former Australian Chief Scientist Alan Finkel states: “Any call to go directly from coal to nuclear is effectively a call to delay decarbonisation of our electricity system by 20 years.”[5]

Likewise, a 2020 report prepared for the NSW Cabinet by NSW Chief Scientist Hugh Durrant-Whyte, a former Chief Scientific Adviser at the UK Ministry of Defence, notes that introducing nuclear power to Australia would be expensive and difficult and that it would be naïve to think a nuclear plant could be built in less than two decades.[6]

Dr. Durrant-Whyte’s report states: "The hard reality is Australia has no skills or experience in nuclear power plant building, operation or maintenance – let alone in managing the fuel cycle. Realistically, Australia will be starting from scratch in developing skills in the whole nuclear power supply chain.”[7]

The Australian Energy Market Operator’s 2024 Integrated System Plan forecasts “the retirement of 90% of Australia’s remaining 21 gigawatts of coal generation by 2034-35, with the entire fleet retired by 2038 … AEMO notes the departure of coal from the grid could be faster still, pointing to higher operating costs, reduced fuel security and high maintenance costs as well as more competition from renewable energy in the wholesale market.”[8]

Alison Reeve, Deputy Program Director, Energy and Climate Change at the Grattan Institute notes: “Australia’s coal-fired power stations are old and unreliable – that’s why their owners want to shut them down. To keep plants open means potentially operating them at a loss, while having to invest in repairs and upgrades.”[9]

Claims that “Australia could have nuclear up and running within a 10-year period” are not supported by the reality of any recent projects in North America or Western Europe, where:
* Construction of the two AP1000 reactors in the **US** state of Georgia took 10 and 11 years (2013 to 2023/24) despite initially promising a 3-4 year construction period.[10] Georgia Power announced it was evaluating the project in 2005 (with the first license application submitted in 2006); if that is taken as the planning start-date, it was 18 years for planning and construction. Work on the AP1000 reactor project began in the 1990s so planning plus construction could be said to have taken 25+ years.[11]

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[5] https://www.theguardian.com/commentisfree/2024/mar/22/heres-why-there-is-no-nuclear-option-for-australia-to-reach-net-zero

[6] https://www.skynews.com.au/australia-news/will-be-starting-from-scratch-report-paints-grim-picture-of-australias-long-road-to-nuclear-power/news-story/dec9f44aed1e82c65f224bb5dd34a959

[7] https://www.skynews.com.au/australia-news/will-be-starting-from-scratch-report-paints-grim-picture-of-australias-long-road-to-nuclear-power/news-story/dec9f44aed1e82c65f224bb5dd34a959

[8] Dylan McConnell, ‘Coal will be all but gone by 2034 under Australia’s latest energy roadmap’, UNSW Newsroom, 15 Dec 2023
https://www.unsw.edu.au/newsroom/news/2023/12/coal-will-be-all-but-gone-by-2034-under-australias-latest-energy

[9] Alison Reeve, ‘Dutton’s nuclear plan would mean propping up coal for at least 12 more years – and we don’t know what it would cost’, The Conversation, 25 September 2024
https://theconversation.com/duttons-nuclear-plan-would-mean-propping-up-coal-for-at-least-12-more-years-and-we-dont-know-what-it-would-cost-239720

[10] https://reneweconomy.com.au/cold-turkeys-the-demise-of-nuclear-power-in-australias-aukus-partner-countries/

[11] https://en.wikipedia.org/wiki/AP1000

* In the **UK**, the only reactor construction project is the twin-reactor Hinkley Point EPR project in Somerset. Construction began in 2018 and the completion date has been pushed back to 2030/31, nearly a quarter of a century after the plan to build new reactors was announced in 2006. Construction will take at least 12-13 years on the current schedule with a high likelihood of further delays.
* The only reactor under construction in **France** is the Flamanville EPR. Construction began in 2007 and the project remains incomplete 17 years later (test operations have begun and EDF hopes the reactor will be fully operational by the end of 2024[12]). Design work on the EPR reactor began in 1989 – 35 years ago.[13]
* In **Finland**, construction of one EPR on Olkiluoto Island began in 2005 and completion was expected in 2009. However grid-connection was not completed until 2022 (and getting from grid connection to commercial operation took one more year).[14] A four-year construction project became a 17-year project. The first license application for the reactor was filed in the year 2000 so planning plus construction took 20+ years.

1.2 SMR timelines

Small modular reactor (SMR) construction timelines have not been impressive. Promoters claim a 3–5 year construction timeline.[15] However:
* Planning for China's so-called SMR (a twin-reactor high-temperature gas-cooled reactor) began in 2001, initial approval was granted in 2005, construction began in 2012 and the expected completion date of 2016 was pushed back several times.[16] The twin reactors achieved first criticality in 2021 with commercial operation commencing in December 2023.[17] Thus, planning to commercial operation spanned 22 years, and construction took nine years as opposed to the initial four-year construction estimate.
* When construction of Russia's floating nuclear power plant began in 2007, completion was anticipated in 2010 but it was not completed until 2019.[18] A three-year construction project became a 12-year project. Planning went back as least as far as the year 2000 and probably earlier. Russia's plan to have seven floating nuclear power plants by 2015 was not realised.[19]
* Construction of Argentina's CAREM SMR began in 2014, at which time completion was expected in 2017. But the reactor remains incomplete and the expected completion date has been pushed back to 2028.[20] A three-year construction project has become a 14-year project and further slippage is certain as construction has stalled due to budget cuts.[21]

[12] https://www.enerdata.net/publications/daily-energy-news/edf-begins-operations-165-gw-flamanville-epr-nuclear-reactor-france.html
[13] https://gala.gre.ac.uk/id/eprint/4699/3/(ITEM_4699)_THOMAS_2010-11-E-EPR.pdf
[14] https://pris.iaea.org/PRIS/CountryStatistics/ReactorDetails.aspx?current=860
[15] https://johnquigginblog.substack.com/p/on-nuclear-coalition-prefers-the
[16] https://en.wikipedia.org/wiki/HTR-PM
[17] https://www.world-nuclear-news.org/Articles/Dual-criticality-for-Chinese-demonstration-HTR-PM
[18] https://www.worldnuclearreport.org/The-World-Nuclear-Industry-Status-Report-2022-HTML.html
[19] https://en.wikipedia.org/wiki/Russian_floating_nuclear_power_station
[20] https://www.reuters.com/business/energy/argentina-budget-cuts-hitting-nuclear-energy-ambitions-atomic-body-says-2024-05-02/
[21] https://www.reuters.com/business/energy/argentina-budget-cuts-hitting-nuclear-energy-ambitions-atomic-body-says-2024-05-02/

Development began in 1980 so if the CAREM reactor is ever completed, it is likely to be a 50+ year project.[22]
* In Canada, SMRs have been promoted for around 20 years but there is still not a single operating SMR, nor any under construction.
* Conceptual design work for South Korea's 'SMART' SMR began in 1997.[23] Over 25 years later, none have been built and none are under construction.
* Development of NuScale SMR technology in the US dates from 2003.[24] In 2023, the company abandoned its flagship project in Idaho before construction began.[25] NuScale is now celebrating its 21st birthday with no reactors in operation, none under construction, ongoing licensing challenges, a class-action lawsuit from shareholders, and bankruptcy looming.

Australian economist Prof. John Quiggin notes that even if SMR proposals "work as planned (a big if), they will arrive too late to replace coal power in Australia."[26] Prof. Quiggin has traced the source of widespread claims of a 3–5 year construction timeline for SMRs.[27] The Australian Nuclear Science and Technology Organisation (ANSTO), operator of the research reactor at Lucas Heights in southern Sydney, notes that short construction times could be achieved using "series-production methods" without noting that no country has the capacity to deploy series-production methods. In defence of its implausible claims, ANSTO cites a University of Leeds paper. Prof. Quiggin discusses ANSTO's "sloppy treatment of an issue that should be a central focus of ANSTO analysis":
"The University of Leeds paper is more interesting. It turns out to be a literature survey covering the period 2004-19. The three- to five-year estimate for the construction time for SMRs is taken from a non-peer-reviewed 2016 report by consulting firm Ernst and Young (which worked with one of the authors on the University of Leeds study). The information used to compile the report is even older, going back to 2014 or earlier. To put it bluntly, this is worthless.
"Rather than complying with its legal obligation to keep abreast of nuclear power technology and inform the public of its findings, ANSTO has relied on decade-old, unverified claims, made by a consulting company."

According to reports in *The Australian*, Rolls-Royce claims it could build a 470-megawatt reactor in Australia in four years[28] and that its reactor technology could be ready for the Australian market by the early to mid-2030s.[29] The claims are implausible. Rolls-Royce does

[22] https://www.neimagazine.com/news/newsnew-agreement-seeks-to-support-argentinas-carem-smr-11261042
[23] http://smart-nuclear.com/tech/d_history.php
[24] https://d3n8a8pro7vhmx.cloudfront.net/oregonpsrorg/pages/21/attachments/original/1600287829/EyesWideShutReport_Final-30August2020.pdf
[25] https://reneweconomy.com.au/coalitions-nuclear-smr-poster-boy-cancels-flagship-project-due-to-soaring-costs/
[26] https://theconversation.com/dutton-wants-a-mature-debate-about-nuclear-power-by-the-time-weve-had-one-new-plants-will-be-too-late-to-replace-coal-224513
[27] https://johnquigginblog.substack.com/p/on-nuclear-coalition-prefers-the
[28] https://www.theaustralian.com.au/nation/politics/peter-dutton-vows-to-bring-small-nuclear-reactors-online-in-australia-by-mid2030-if-elected/news-story/eaf9eaf2084916fa118fbeebf2ed72c9
[29] https://www.theaustralian.com.au/nation/politics/peter-dutton-vows-to-bring-small-nuclear-reactors-online-in-australia-by-mid2030-if-elected/news-story/eaf9eaf2084916fa118fbeebf2ed72c9

not yet have a licenced design let alone an operating SMR or even an SMR under construction.

Assuming construction of a Rolls-Royce SMR in Australia did not begin until after one was completed in the UK or elsewhere, it would not be possible for Rolls-Royce SMRs to provide power in Australia by the mid-2030s. Alternatively, a decision to build Rolls-Royce SMRs in Australia could make Australia the testing ground for these reactors given the lack of progress elsewhere.[30] Prof. Quiggin notes:[31]
"Australia could be in the unenviable situation of building "first of a kind" (FOAK) reactors with an untested design. Even more than nuclear plants in general, FOAK projects are notorious for delays and cost overruns. For a country like Australia, with no established nuclear industry or regulatory structure, it would be madness to try such a thing."

Former Chief Scientist Dr. Alan Finkel provides this reality check regarding SMRs:[32]
"In Australia, we would be looking to use SMRs because of the enormous cost and construction delays of large-scale nuclear plants. But we will want the reassurance of first seeing SMRs work safely and well in the UK, Europe, Canada, the US or another OECD country.
"The trouble is, there are no SMRs operating in the UK, Europe, Canada, the US or any other OECD country. Nor are any SMRs under construction or approved in an OECD country.
"There is no data to support any claims about how much SMRs will cost when deployed as operating power stations."

NSW Chief Scientist Hugh Durrant-Whyte points to the extreme delays and cost overruns associated with the Hinkley Point reactor construction project in the UK and notes that it "would be naive to expect that any new reactor designs – including SMRs – in a completely new environment, like Australia, will be any cheaper or any quicker to approve and get operational."[33]

Dr. Durrant-Whyte says SMRs are "not likely to be the panacea people are expecting – they still entail regulation, fuel supply, maintenance and operation – and are currently estimated to cost at least as much per conventional reactors per Megawatt delivered."[34]

In 2021 the former Chair of the US Nuclear Regulatory Commission, Prof. Allison Macfarlane, put the situation clearly, stating that "when it comes to averting the effects of climate change, the cutting edge of nuclear technology will prove to be too little, too late".[35]

[30] https://www.crikey.com.au/2024/04/10/nuclear-power-peter-dutton-technology-dead-ends/
[31] https://www.crikey.com.au/2024/04/10/nuclear-power-peter-dutton-technology-dead-ends/
[32] https://www.theguardian.com/commentisfree/2024/mar/22/heres-why-there-is-no-nuclear-option-for-australia-to-reach-net-zero
[33] https://www.skynews.com.au/australia-news/will-be-starting-from-scratch-report-paints-grim-picture-of-australias-long-road-to-nuclear-power/news-story/dec9f44aed1e82c65f224bb5dd34a959
[34] https://www.skynews.com.au/australia-news/will-be-starting-from-scratch-report-paints-grim-picture-of-australias-long-road-to-nuclear-power/news-story/dec9f44aed1e82c65f224bb5dd34a959
[35] https://www.foreignaffairs.com/world/nuclear-energy-will-not-be-solution-climate-change

1.3 The UAE nuclear project as a model for Australia?

It is frequently claimed that the four-reactor project in the UAE was completed on time and on budget. It was not. The decision to build reactors in the UAE was announced in 2008[36], construction began in 2012, and the four reactors were grid-connected in 2020, 2021, 2022 and 2024. Thus, the time from announcement to grid connections ranged from 12 to 16 years. Construction to grid connection averaged 8.4 years.[37] The first reactor was expected to be supplying power in 2017 and the others in 2018, 2019 and 2020.[38] The project was three years behind schedule, and the fourth reactor was four years behind schedule.

Claims that the "UAE went from a decision to having nuclear on the grid within 10 years" and that the project (delivered by South Korea) was "on time and on budget" are not supported by the facts.[39]

Further, Australia could not match the timeline achieved in the UAE for a myriad of reasons including the authoritarian nature of the UAE political system, and the employment of a large, mostly-foreign workforce with few rights. Prof. Quiggin states:[40]
"Would it be possible to match the UAE schedule? The UAE had no need to pass legislation: it doesn't have a parliament like ours, let alone a Senate that can obstruct government legislation. The necessary institutions, including a regulatory commission and a publicly owned nuclear power firm, were established by decree.
"There were no problems with site selection, not to mention environmental impact statements and court actions. The site at Barakah was conveniently located on an almost uninhabited stretch of desert coastline, but still close enough to the main population centres to permit a connection to transmission lines, access for workers, and so on. There's nowhere in Australia's eastern states (where the power is needed) that matches that description.
"Finally, there are no problems with strikes or union demands: both are illegal in the UAE. Foreign workers with even less rights than Emirati citizens did almost all the construction work.
"Despite all these advantages, the UAE has not gone any further with nuclear power. Instead of building more reactors after the first four, it's investing massively in solar power and battery storage."

The UAE project was not completed on time, nor was it completed on budget. The stated aim of completing the four reactors at a total cost of US$20 billion was not achieved. The World Nuclear Industry Status Report states that the cost of the 5.2 GW nuclear plant could be as much as US$40 billion (A$61.6 billion) including fuel management and operation.[41] Moreover, the agreement between South Korea and the UAE included non-quantifiable

[36] https://www.enec.gov.ae/about-us/overview/the-uae-nuclear-energy-policy/
[37] https://pris.iaea.org/PRIS/CountryStatistics/CountryDetails.aspx?current=AE
[38] https://www.worldnuclearreport.org/The-World-Nuclear-Industry-Status-Report-2021-HTML.html#_idTextAnchor215
[39] https://www.abc.net.au/news/2024-03-12/coalition-pushing-for-nuclear-energy/103579316
[40] https://theconversation.com/dutton-wants-a-mature-debate-about-nuclear-power-by-the-time-weve-had-one-new-plants-will-be-too-late-to-replace-coal-224513
[41] https://www.worldnuclearreport.org/IMG/pdf/20160713MSC-WNISR2016V2-HR.pdf

components such as a secret military side-agreement, signed without the knowledge or approval of South Korea's National Assembly.[42]

The UAE is now prioritising renewables and the UAE Energy Strategy 2050 aims for a 44% renewable electricity share compared to a 6% nuclear share.[43]

South Korea's ambition to secure overseas orders for 80 power reactors by 2030 has not progressed.[44] South Korea has not secured any export orders whatsoever since the 2009 UAE deal, although Korea Hydro & Nuclear Power has recently been selected by the Czech Republic as the preferred bidder for the construction of new nuclear reactors.

An industry-wide corruption scandal has severely diminished both domestic and international confidence in South Korea's nuclear industry.[45] In addition to increased safety risks due to corruption – such as the installation of safety-related equipment on the basis of falsified documentation[46] – the design of South Korea's AP1400 reactors has been challenged. In 2010, Areva CEO Anne Lauvergeon likened the AP1400 design to "a car without airbags and safety belts."[47]

2. FUEL SUPPLY, AND TRANSPORT OF FUEL

A 2020 report prepared for the NSW Cabinet by NSW Chief Scientist Hugh Durrant-Whyte, a former Chief Scientific Adviser at the UK Ministry of Defence, noted that it is *"important to dispel a significant myth propagated through the [NSW nuclear power] inquiry[48] that having large local uranium reserves is a driver for low-cost nuclear power. Most costs associated with the manufacture of fuel has little to do with the cost of uranium. It has much to do with enriching the fuel, manufacture of fuel rods... reprocessing of the spent fuel and storage of waste."*[49]

Australian engineer Peter Farley writes:[50]
"People often ask why Australia does not have nuclear power because we have a lot of uranium. The first part of the answer is that the question is like asking why don't we make semiconductors, we have a lot of sand which is the ore for silicon or perhaps even simpler why don't farmers control the bread market? The value of refined uranium ore (yellowcake) that we export is around 10% of the finished fuel assembly and in turn the fuel is less than 10% of the cost of nuclear power so in effect we control about 1% of the cost."

[42] https://thediplomat.com/2018/03/risky-business-south-koreas-secret-military-deal-with-uae/
[43] https://www.uae-embassy.org/discover-uae/climate-and-energy/uae-energy-diversification
[44] https://www.brookings.edu/wp-content/uploads/2016/06/ROK-US-Civil-Nuclear-and-Nonproliferation-Collaboration-in-Third-Countries.pdf
[45] https://jimkgreen1.substack.com/p/south-koreas-nuclear-mafia
[46] https://wiseinternational.org/nuclear-monitor/878/south-koreas-corrupt-and-dangerous-nuclear-industry
[47] https://www.wiseinternational.org/nuclear-monitor/844/south-koreas-nuclear-industry-model-others-follow
[48] https://www.parliament.nsw.gov.au/committees/inquiries/Pages/inquiry-details.aspx?pk=2525
[49] https://www.skynews.com.au/australia-news/will-be-starting-from-scratch-report-paints-grim-picture-of-australias-long-road-to-nuclear-power/news-story/dec9f44aed1e82c65f224bb5dd34a959
[50] https://www.openforum.com.au/is-nuclear-power-a-solution-for-australia/

Australia has significant uranium reserves and operating uranium mines, but no capacity for uranium conversion (or deconversion), no capacity for uranium enrichment, and no capacity for fuel fabrication.

Nuclear transport incidents and accidents are commonplace in countries with a significant nuclear industry. A British study identified 806 radioactive transport incidents in the UK from 1958−2004 including incidents involving medical and industrial isotopes (376), residues including discharged irradiated nuclear fuel flasks (111), irradiated fuel (101), radiography sources (78), radioactive wastes (63), uranium ore concentrate (33) and 'other' (44).[51]

There are no comparable studies of transport accidents and incidents involving radioactive materials in Australia. However numerous accidents and incidents have been reported over the years (see section 4.8).

3. URANIUM ENRICHMENT CAPABILITY

The Australian newspaper reported that shadow energy minister Ted O'Brien has "a longer-term plan to develop expertise across the front end of the nuclear fuel cycle that would involve the development of a uranium-enrichment industry."[52] The plan is reportedly aimed at Australia developing self-sufficiency with no reliance on global fuel chains. For that aim to be achieved, Australia would not only need to develop an enrichment capability but also uranium conversion (and deconversion) and fuel fabrication capabilities – as well as capabilities for the long-term management of radioactive wastes generated across the nuclear fuel cycle.

The Australian quoted Mr. O'Brien saying:
"As Australia establishes its own civil nuclear program, we should aspire to build sovereign capability beyond the mining and milling of uranium to include conversion and enrichment through to fuel fabrication for civil nuclear power plants.
"It's not about standing up an end-to-end supply chain ahead of Australia establishing its initial nuclear power plants in the mid to late 2030s, but treating sovereign capability as the ultimate goal from the very start.
"Advancing Australia in this direction would set Australia up for the future, not just economically, but also strategically."

It would be helpful if Mr O'Brien could explain the use of the term 'strategically' in the above context. Is it an oblique reference to the dual-use nature of some nuclear facilities, in particular the fact that uranium enrichment provides an immediate pathway to fissile material (highly-enriched uranium)? If not, what is meant by the term 'strategically'?

[51] https://assets.publishing.service.gov.uk/media/5a7ebb6fed915d74e33f2126/HpaRpd014.pdf
[52] https://www.theaustralian.com.au/nation/politics/ted-obrien-sets-out-longterm-plan-for-uraniumenrichment-industry/news-story/d32f97b45c98da9a8001925cd0490699

Mr O'Brien is also quoted saying:
"In addition to the 32 economies currently using zero-emissions nuclear energy, another 50 are looking at introducing the energy source for the very first time, including in our part of the world."
"For geo-strategic reasons as much as economic reasons, it's not in our national interest to be passive bystanders on the deployment of nuclear energy across our own region. Instead, we can and should be active participants working together with our friends and allies."

Again, those statements need explanation. Moreover the claim (or assumption) that nuclear power is likely to be deployed in "our part of the world" is dubious. No country in south-east Asia operates nuclear power reactors and it is unlikely that any will do so in the foreseeable future. It could reasonably be said that some countries in the region are "looking" at nuclear power (e.g. Vietnam, Indonesia, Malaysia, the Philippines) but it is unlikely that projects will proceed for economic reasons among others. For example Vietnam was pursuing a nuclear power program but it was abandoned in 2016.[53] A reactor was built but never fuelled or operated in the Philippines.[54] In Indonesia, nuclear power has repeatedly been considered over the decades but no power reactors have been built[55] and it is unlikely that nuclear power projects will proceed for economic reasons among others. The same could be said for every country in south-east Asia: it is unlikely that nuclear power projects will proceed for economic reasons among others.

Rod Lyon of the Australian Strategic Policy Institute has commented on the proliferation implications of developing an enrichment capacity:[56]
"True, an Australian enrichment capability would also be a strategic signal. It would constitute a hedge against any sharp deterioration in the regional security environment – a hedge similar to that enjoyed by a range of other countries around the world and in all likelihood one we'll never need, because we're already protected by US nuclear weapons under the ANZUS alliance."

The development of a weapons capability in Australia – or more precisely a fissile material production capability – via an enrichment program could encourage other countries to pursue the same path.

Nuclear fuel cycle issues were considered by the South Australian Nuclear Fuel Cycle Royal Commission. In relation to uranium conversion, enrichment and fuel fabrication, the Commission concluded in its 2016 Final Report that there are "significant barriers to entering these commercial markets" and "these markets are currently over-supplied".[57]

[53] https://web.archive.org/web/20240304175508/https://www.wiseinternational.org/nuclear-monitor/834/vietnam-cancels-nuclear-power-program
[54] https://en.wikipedia.org/wiki/Bataan_Nuclear_Power_Plant
[55] https://world-nuclear.org/information-library/country-profiles/countries-g-n/nuclear-power-in-indonesia
[56] Rod Lyon, 'Australia and the enrichment option', The Strategist, The Australian Strategic Policy Institute, 5 Nov 2015
https://www.aspistrategist.org.au/australia-and-the-enrichment-option/
[57] https://nuclear.foe.org.au/wp-content/uploads/NFCRC_Final_Report_Web_5MB.pdf

Little has changed since 2016. The World Nuclear Association notes that "in recent years there has been a significant surplus of world enrichment capacity".[58] There is no reason to believe that companies involved in uranium enrichment, such as Orano or Urenco, would see any value in establishing an enrichment plant in Australia.

The World Nuclear Association further notes that in response to Russia's 2022 invasion of Ukraine, and efforts to reduce reliance on Russia's uranium enrichment operations, Urenco is upgrading capacity at existing enrichment plants and Orano is studying possibilities to expand its enrichment capacity.[59]

The 2020 report prepared for the NSW Cabinet by NSW Chief Scientist Hugh Durrant-Whyte, a former Chief Scientific Adviser at the UK Ministry of Defence, noted: [60]
"Enrichment is very unlikely to ever be undertaken in Australia due to cost, skills and non-proliferation agreements. Consequently, we will still need to send our mined uranium overseas to be enriched – and probably converted into fuel rods, which we will then need to import."

Australia has been involved in laser enrichment R&D, which poses greater proliferation risks than centrifuge enrichment.[61] However it is doubtful whether laser enrichment processes will progress to commercial operations and still less likely that commercial operations would be based in Australia. In addition to the major commercial barriers, uranium enrichment is currently illegal in Australia (Australian Radiation Protection and Nuclear Safety Act 1998; Environment Protection and Biodiversity Conservation Act 1999) and it is also banned by state laws in NSW, Victoria and SA.[62]

Global Laser Enrichment (GLE) hopes to complete a pilot demonstration project in the US by the mid-2020s, after which a feasibility assessment will be conducted for the proposed Paducah Laser Enrichment Facility, also in the US.[63] GLE, the exclusive worldwide licensee of SILEX technology, states that GLE was formed to develop and commercialise laser uranium enrichment technology specifically in the US.

A Treaty between the US and Australia dealing with SILEX laser enrichment technology states:
"Cooperation under this Agreement within the territory of Australia shall be limited to research on and development of SILEX technology, and shall not be for the purpose of

[58] https://world-nuclear.org/information-library/nuclear-fuel-cycle/conversion-enrichment-and-fabrication/uranium-enrichment
[59] https://world-nuclear.org/information-library/nuclear-fuel-cycle/conversion-enrichment-and-fabrication/uranium-enrichment
[60] https://www.skynews.com.au/australia-news/will-be-starting-from-scratch-report-paints-grim-picture-of-australias-long-road-to-nuclear-power/news-story/dec9f44aed1e82c65f224bb5dd34a959
[61] R. Scott Kemp, 'SILEX and proliferation', Bulletin of the Atomic Scientists, 30 July 2012 https://thebulletin.org/2012/07/silex-and-proliferation/
[62] https://www.aph.gov.au/About_Parliament/Parliamentary_departments/Parliamentary_Library/Research/Quick_Guides/2023-24/NuclearActivitiesProhibitions
[63] https://world-nuclear.org/information-library/nuclear-fuel-cycle/conversion-enrichment-and-fabrication/uranium-enrichment#SILEX

constructing a uranium enrichment facility in Australia unless provided for by an amendment to this Agreement."[64]

Regarding fuel fabrication, the World Nuclear Association noted in 2021:[65]
"Most of the main fuel fabricators are also reactor vendors (or owned by them) … Currently, fuel fabrication capacity for all types of LWR fuel throughout the world considerably exceeds the demand. It is evident that fuel fabrication will not become a bottleneck in the foreseeable supply chain for any nuclear renaissance. The overcapacity is increased by countries such as China, India and South Korea aiming to achieve self-sufficiency."

4. WASTE MANAGEMENT, TRANSPORT AND STORAGE

"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.[66]

4.1 Introduction and summary

Efforts to establish national radioactive waste facilities (repositories and stores) in Australia for low- and intermediate-level waste have repeatedly failed since the 1990s. Decades of failure do not inspire confidence that far more complex high-level nuclear waste challenges from a nuclear power program would be responsibly managed in Australia.

[64] Agreement for Cooperation between the Government of Australia and the Government of the United States of America concerning Technology for the Separation of Isotopes of Uranium by Laser Excitation [SILEX Agreement], 2000, Article 2.3
http://www.austlii.edu.au/au/other/dfat/treaties/2000/19.html
[65] World Nuclear Association, 'Nuclear Fuel and its Fabrication', last updated 13 October 2021
https://world-nuclear.org/information-library/nuclear-fuel-cycle/conversion-enrichment-and-fabrication/fuel-fabrication
[66] Alan Parkinson, 2002, 'Double standards with radioactive waste', Australasian Science,
https://nuclear.foe.org.au/flawed-clean-up-of-maralinga/

A nuclear power program would generate significant streams of low-, intermediate- and high-level nuclear waste. A demonstrated ability to manage Australia's current radioactive waste challenges would be necessary to establish confidence that Australia could manage the waste arising from a nuclear power program. However, Australia's current radioactive waste challenges are either being mismanaged or not managed at all. (See section 4.2 below.)

Some nuclear power proponents argue that nuclear waste from power reactors is a non-issue since comparable facilities will be required for the AUKUS nuclear submarine program. That argument is circular and it ignores relevant facts: Australia has no national facilities for nuclear waste management and no country in the world has an operating repository for the disposal of high-level nuclear waste. (See section 4.3 below.)

There are currently no operating deep underground repositories for high-level nuclear waste anywhere in the world. (See section 4.4 below.)

Costs estimates for long-term high-level nuclear waste management run into the tens or hundreds of billions of dollars. For example 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$148 billion). Moreover, cost estimates for long-term high-level nuclear waste management have increased dramatically. (See section 4.5 below.)

There is one operating deep underground repository for long-lived intermediate-level nuclear waste − the Waste Isolation Pilot Plant (WIPP) in the US state of New Mexico. However, the WIPP repository was shut for three years following a chemical explosion in an underground radioactive waste barrel in 2014, a result of inept management and inadequate regulation. (See section 4.6 below.)

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. On the contrary, they would generate more waste per unit of energy generated than large reactors. (See section 4.7 below.)

Claims that certain Generation IV reactor concepts (as opposed to conventional light-water reactor technology) promise major advantages with respect to nuclear waste management are baseless. (See section 4.7 below.)

In countries with a significant nuclear industry, nuclear waste transport accidents and incidents are commonplace and the same can be expected in Australia. (See section 4.8 below.)

Efforts to establish a high-level nuclear waste import industry in Australia – firstly by Pangea Resources around the turn of the century, and then by the SA government following the completion of the SA Nuclear Fuel Cycle Royal Commission in 2016 – were defeated and abandoned by the proponents. (See section 4.9 below.)

Opposition Leader Peter Dutton claims that: “If you look at a 450-megawatt reactor, it produces waste equivalent to the size of a can of Coke each year.” In fact, over 450 million empty Coke cans per year would be required to accommodate waste generated across the nuclear fuel cycle for the operation of one 450-megawatt reactor for one year; excluding front-end waste (at uranium mines and enrichment plants), 367,000 empty Coke cans per year would be required; and just the spent nuclear fuel alone would require about 11,700 empty Coke cans per year. (See section 4.10 below.)

4.2 Australia’s radioactive waste management failures

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]."[67]

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.[68] Over a 50-year lifespan, a 50-reactor (50-gigawatt) nuclear power program would:[69]
* 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.

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:

- Federal governments failed in their attempts to impose a national radioactive waste repository and store on unwilling communities in SA (Woomera: 1998–2004), the NT (Muckaty: 2005–2014), SA again (Flinders Ranges: 2016–19) and SA yet again (Kimba: 2017–23).
- The management of radioactive tailings waste at past and current uranium mines has been deficient in many respects.[70] Cases in point here include continuing contamination concerns at both Mary Kathleen (Queensland) and Rum Jungle (NT).

[67] Switkowski Review, 2006, Uranium Mining, Processing and Nuclear Energy Review, http://pandora.nla.gov.au/tep/66043
[68] 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
[69] 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
[70] 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

- 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.[71]
- The Port Pirie uranium treatment plant in SA is still contaminated over 50 years after its closure.[72] 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.
- SA regulators failed to detect Marathon Resource's illegal dumping of low-level radioactive waste in the Arkaroola Wilderness Sanctuary.[73] 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.
- 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.[74] Four scientists with first-hand information were highly critical of the 'clean up'.[75] The area remains the focus of continuing publicly funded remediation work.
- CSIRO faced a 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.[76]

Former Liberal Party Senator Nick Minchin has commented on the difficulty of managing wastes from a nuclear power program:[77]
''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, former federal Resources Minister Matt Canavan noted in 2019:[78]
"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."

[71] 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
[72] Ibid.
[73] Ibid.
[74] Numerous articles on the flawed 'clean up' are posted at https://nuclear.foe.org.au/flawed-clean-up-of-maralinga/
[75] https://nuclear.foe.org.au/flawed-clean-up-of-maralinga/
[76] See the information posted at https://nuclear.foe.org.au/woomera/
[77] Brad Crouch, 21 May 2006, 'No nuke plant in 100 years', The Advertiser.
[78] 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

As noted above, successive federal governments have tried but failed to establish a national radioactive waste repository for low-level waste and an interim store for long-lived intermediate-level waste. A cooperative, inclusive approach to radioactive waste management is likely to be more effective than the failed approaches of successive federal governments. That is a lesson being learned around the world – but not yet in Australia.

Australia has a long and complex engagement with nuclear waste issues. A recurring theme is the violation of the rights of Aboriginal First Nations Peoples and their successful efforts to resist the imposition of nuclear waste facilities on their traditional lands through effective community campaigning and legal challenges. The UN Declaration on the Rights of Indigenous Peoples should be incorporated into Australian law including the requirement for free, prior and informed consent. Further, amendments to the National Radioactive Waste Management Act should be made to remove clauses which weaken or override indigenous cultural heritage protections and land rights. In addition, there is a need for studies, clean-up and monitoring of all British nuclear weapons test sites in Australia in line with the positive obligations in the Treaty on the Prohibition of Nuclear Weapons (TPNW).

For a longer discussion on the above-mentioned issues, please see:
Jim Green and Dimity Hawkins, 2024, 'The Politics of Nuclear Waste Disposal: Lessons from Australia', Asia-Pacific Leadership Network report,
https://www.apln.network/projects/voices-from-pacific-island-countries/the-politics-of-nuclear-waste-disposal-lessons-from-australia

4.3 AUKUS waste

Some nuclear power proponents argue that nuclear waste is a non-issue since comparable facilities will be required for the AUKUS nuclear submarine program.

That argument is circular. It could equally be argued that management of waste from a nuclear submarine program is a non-issue since comparable facilities would be required for a nuclear power program or for existing operations at ANSTO's Lucas Heights site which generate low-level waste destined for shallow burial and long-lived intermediate-level waste destined for deep underground burial.

All variations of those arguments are circular and ignore key facts: Australia has no national facilities for nuclear waste management and no country in the world has an operating repository for the disposal of high-level nuclear waste.

4.4 Global challenges

There are no operating repositories for high-level nuclear waste anywhere in the world. Finland and Sweden are the countries most advanced with deep geological repository projects. Finland's nuclear waste management program was initiated in 1983.[79] Forty-one

[79] https://world-nuclear.org/information-library/country-profiles/countries-a-f/finland

years later, Finnish radioactive waste management company Posiva Oy has applied for an operating licence for its used fuel encapsulation and final disposal facility.[80]

In Sweden, the Swedish Nuclear Fuel and Waste Management Company (SKB) was set up by nuclear utilities following the Waste Legislation (Stipulation Act) in 1977 to develop a comprehensive plan for waste management.[81] Forty-seven years later, the World Nuclear Association reports that SKB "hopes to commence the ten-year construction [for a deep underground repository] in the mid-2020s."[82]

Other countries operating nuclear power plants – including the US, the UK, Japan, South Korea, etc. – have not even established a site for a high-level nuclear waste repository, let alone commenced construction or begun operation or demonstrated safe operation over any length of time. One example of a protracted, expensive and failed attempt to establish a high-level nuclear waste repository can be seen in the plan for a repository at Yucca Mountain in Nevada. This was abandoned in 2009. 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 modelling. 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.[83]

A 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.[84]

4.5 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.[85] For example, the construction cost estimate in France was €25 billion (A$40.6 billion) as of 2016, far higher than the 2005 estimate of €13.5–16.5 billion.[86]

[80] https://world-nuclear.org/information-library/country-profiles/countries-a-f/finland, http://wna.informz.ca/z/cjUucD9taT0xNDE0NTM3JnA9MSZ1PTkwOTg5NjAyMSZsaT0yODc3MTg5Nw/index.html

[81] https://world-nuclear.org/information-library/country-profiles/countries-o-s/sweden

[82] https://world-nuclear.org/information-library/country-profiles/countries-o-s/sweden, https://world-nuclear-news.org/articles/environmental-permit-granted-for-swedish-repository

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

[84] 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/

[85] Ibid.

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

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$109 billion) to over £100 billion (A$195 billion).[87]

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$148 billion), a 67% increase on the 2001 estimate.[88]

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.[89]

4.6 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."[90]

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$3.1 billion).[91]

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

[87] 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
[88] 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
[89] Nuclear Fuel Cycle Royal Commission Report, May 2016, https://nuclear.foe.org.au/wp-content/uploads/NFCRC_Final_Report_Web_5MB.pdf
[90] 6 June 2014, 'Fire and leaks at the world's only deep geological waste repository', Nuclear Monitor #787, www.wiseinternational.org/node/4245
[91] https://www.latimes.com/nation/la-na-new-mexico-nuclear-dump-20160819-snap-story.html

the radiological hazard ... compounded by degradation of key safety management programs and safety culture."[92]

A safety analysis conducted before WIPP opened predicted that one radiation release accident might occur every 200,000 years.[93] 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 afraid the emphasis shifted to looking at how quickly and how inexpensively they could dispose of this waste."[94] 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."[95]

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

4.7 Small modular reactors and 'Generation IV' reactor waste

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."[96]

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[92] 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

[93] 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

[94] 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

[95] ibid.

[96] https://nuclear.foe.org.au/wp-content/uploads/NFCRC_Final_Report_Web_5MB.pdf

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."[97]

One of the authors of the above-mentioned article, Prof. 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."[98]

A 2016 European Commission document states:[99]
"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 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)."

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.[100] 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."

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[97] 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
[98] 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
[99] 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
[100] 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

Krall and Macfarlane 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 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."

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[101] and a longer report[102] by the Union of Concerned Scientists' senior scientist Dr. Edwin Lyman, drawing on documents obtained under Freedom of Information legislation.

Dr. Lyman writes:[103]
"[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."

4.8 Transportation of radioactive waste

Nuclear waste transport accidents and incidents are discussed in detail in a 2023 submission by environment groups to the Senate Environment and Communications Legislation Committee.[104]

In countries with a significant nuclear industry, nuclear waste transport accidents and incidents are commonplace. A UK government database – the Radioactive Material Transport Event Database − contains information on 1018 incidents from 1958 to 2011 (an

[101] Ed Lyman / Union of Concerned Scientists, 12 Aug 2017, 'The Pyroprocessing Files', http://allthingsnuclear.org/elyman/the-pyroprocessing-files
[102] 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
[103] Ed Lyman / Union of Concerned Scientists, 12 Aug 2017, 'The Pyroprocessing Files', http://allthingsnuclear.org/elyman/the-pyroprocessing-files
[104] https://www.aph.gov.au/DocumentStore.ashx?id=e6d63b51-45cb-4720-a27b-9dab61f2fe66&subId=732042

average of 19 incidents each year) involving all forms of radioactive and nuclear materials. Of the 38 incidents in the UK in 2011 alone, 11 involved irradiated nuclear fuel flasks.[105]

A report on 806 recorded radioactive transport incidents in the UK from 1958−2004 found that 111 involved residues inc. discharged irradiated nuclear fuel flasks', 101 involved irradiated fuel, and 63 involved (other) radioactive wastes.[106]

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.[107] 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.

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.[108]

There is no comparable database of radioactive transport accidents in Australia. One example of problems with the movement of radioactive waste was revealed in the late 1990s. 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 radiation doses (up to 0.5 mSv).[109]

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[105] 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/

[106] https://assets.publishing.service.gov.uk/media/5a7ebb6fed915d74e33f2126/HpaRpd014.pdf

[107] https://www.researchgate.net/publication/233703871_IRSN_draws_lessons_from_transport_events_involving_radioactive_material_occurring_in_France_between_1999_and_2007

[108] 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

[109] ANSTO, 28 Oct 1999, 'Recent Operational Events'. ARPANSA, 1998-99 Annual Report. ARPANSA, Second quarterly report of the Chief Executive Officer for the period 1 April to 30 June 1999

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

Transportation of radioactive materials (including nuclear waste) also poses security risks.[111] Hirsch et al. summarise some of the security risks associated with the transport of nuclear materials:[112]
"During transport, radioactive substances are a potential target for terrorists. Of the numerous materials being shipped, the following are the most important:
1. Spent fuel elements from nuclear power plants and highly active wastes from reprocessing (high specific inventory of radioactive substances)
2. Plutonium from reprocessing (high radiotoxicity, particularly if released as aerosol)
3. Uranium hexafluoride – uranium has to be converted into this chemical form in order to undergo enrichment (high chemical toxicity of released substances, resulting in immediate health effects in case of release).
"Since the amounts transported with one shipment are about several tonnes at most, the releases to be expected will be smaller by orders of magnitudes than those that result from attack of a storage facility – even if the transport containers are severely damaged. On the other hand, the place where the release occurs cannot be foreseen, as attacks can occur, in principle, 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 a joint submission to the SA Nuclear Fuel Cycle Royal Commission.[113]

Costs of transport 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.[114]

[110] ANSTO, 2003, Submission to NSW Parliament's 'Joint Select Committee into the Transportation and Storage of Nuclear Waste'
[111] https://www.researchgate.net/publication/262630918
[112] 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
[113] https://nuclear.foe.org.au/wp-content/uploads/NFCRC-submission-FoEA-ACF-CCSA-FINAL-AUGUST-2015.pdf
[114] 7 July 2000, www.state.nv.us/nucwaste/news2000/nn10719.htm

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.[115]

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$3.1 billion).[116]

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.[117] 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:[118]
"There are two scandals, both unprecedented. The first lies in the fact that for 15 years the nuclear industry – power plants, transport companies, plutonium factories and nuclear safety institutes in France, Germany, Switzerland and the UK at least – have managed to hide the fact that the international transport regulations for spent fuel shipments have been constantly violated, up to levels exceeding several thousand times the limit. This is all the more stunning as the original recommendation stems from the industry friendly, heavily pro-nuclear International Atomic Energy Agency (IAEA) in Vienna.
"The second scandal derives from the fact that the French nuclear safety authority DSIN has been aware of the problem since autumn 1997, agreed with the French nuclear industry representatives over the wording of a mere "cleanliness problem", and kept silent until a journalistic investigation brought the story to light. The safety authority neither informed its ministers nor its foreign counterparts and, of course, nor did it inform the public. Worse, when the story broke, the authority played the role of the tough transparent State control agency finally cleaning up ... without actually taking any kind of regulatory or disciplinary consequences, while downplaying health consequences and the persistent outrageous violation of regulations.

[115] www.nuclearfiles.org/menu/timeline/timeline_page.php?year=2004
[116] https://www.latimes.com/nation/la-na-new-mexico-nuclear-dump-20160819-snap-story.html
[117] 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
[118] 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

"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:[119]
"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 radioactive waste transport accidents and incidents

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

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 assist. The cargo was reportedly undamaged. The waste was from the Dounreay experimental nuclear power plant.[120] 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."[121]

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

[119] http://www.wise-paris.org/english/ournewsletter/6_7/no6_7.pdf
[120] 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
[121] Herald, 30 July 2014 www.heraldscotland.com/news/home-news/plans-for-radioactive-waste-by-sea-are-criticised.24898732

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."[122]

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.[123]

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.[124]

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.[125]

A serious incident occurred in the UK in 2002.[126] 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

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[122] 6 June 2014, 'Fire and leaks at the world's only deep geological waste repository', Nuclear Monitor #787, www.wiseinternational.org/node/4245

[123] 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

[124] International Panel on Fissile Materials, 21 Jan 2014,
http://fissilematerials.org/blog/2014/01/nuclear_train_accident_in.html

[125] AP, 9 Sept 2002, 'WIPP truck runs off highway in Wyoming',
http://lubbockonline.com/stories/090902/upd_075-3941.shtml

[126] 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

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: 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 kilometres 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.[127]

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.[128]

More information on transport incidents and accidents can be found here:
* 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.[129]
* '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

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

4.9 High-level nuclear waste import

The 2015/16 SA Nuclear Fuel Cycle Royal Commission had a significant level of pro-nuclear bias[130] 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 large volumes 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 against the proposal.[131] The SA Liberal Opposition announced its intention to campaign against the proposal. Then 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".[132]

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.[133] 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[134] 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."[135]

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:

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[130] '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/

[131] Citizens' Jury report: http://web.archive.org/web/20220306105550/http://assets.yoursay.sa.gov.au/production/2016/11/06/07/20/56/26b5d85c-5e33-48a9-8eea-4c860386024f/final%20jury%20report.pdf

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

[133] http://web.archive.org/web/20220306105615/http://assets.yoursay.sa.gov.au/production/2016/11/11/09/37/34/0c1d5954-9f04-4e50-9d95-ca3bfb7d1227/NFCRC%20CARA%20Community%20Views%20Report.pdf

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

[135] http://web.archive.org/web/20220306105550/http://assets.yoursay.sa.gov.au/production/2016/11/06/07/20/56/26b5d85c-5e33-48a9-8eea-4c860386024f/final%20jury%20report.pdf

"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."[136]

The House Select Committee may receive submissions arguing that Australia should import high-level nuclear waste which could be converted into fuel for 'integral fast reactors'.[137] The SA Nuclear Fuel Cycle Royal Commission investigated such proposals and concluded:[138]
"[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, TerraPower's plan for a demonstration fast reactor in China, NuScale's abandonment of its flagship project in Idaho, Ultra Safe Nuclear Corporation's bankruptcy filing, etc. Further, The UK government abandoned consideration of 'integral fast reactors' for plutonium disposition in 2019 – and the US government did the same in 2015.

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?"[139]

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, then 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".[140]

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

[136] http://www.parliament.sa.gov.au/Committees/Pages/Committees.aspx?CTId=2&CId=333
[137] https://www.aph.gov.au/DocumentStore.ashx?id=9eee9d5f-4362-4b30-b0b8-3b65ff98215f&subId=670271
[138] https://nuclear.foe.org.au/wp-content/uploads/NFCRC_Final_Report_Web_5MB.pdf
[139] http://www.abc.net.au/news/2016-11-08/should-south-australia-be-storing-nuclear-waste-above-ground/8003156
[140] http://www.abc.net.au/news/2016-11-03/radioactive-waste-dump-would-boost-sa-economy-commission-hears/7991170

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 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".[141]

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."[142]

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.[143]

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

4.10 Coke can comparisons

Federal opposition leader Peter Dutton has repeatedly claimed that: “If you look at a 450-megawatt reactor, it produces waste equivalent to the size of a can of Coke each year.”[144]

Here are the figures on waste generated across the nuclear fuel cycle to operate one conventional light-water uranium reactor (1,000 megawatts (MW) or 1 gigawatt (GW)) for one year:
1. Hundreds of thousands of tonnes of low-level radioactive tailings waste at uranium mines (unless it is an in-situ leach mine, which doesn't produce tailings waste but does pollute groundwater e.g. the Beverley Four Mile and Honeymoon mines in SA[145]).

[141] http://nuclear-economics.com/wp-content/uploads/2016/11/2016-11-11-NECG-Review-of-Jacobs-MCM-Report-for-SA-Parliament.pdf
[142] 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/
[143] 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
[144] https://www.smh.com.au/politics/federal/dutton-s-claim-nuclear-waste-would-be-size-of-coke-can-hard-to-swallow-20240621-p5jnmy.html
[145] https://nuclear.foe.org.au/in-situ-leach-uranium-mining/

Here's a rough calculation: 10 million tonnes of low-level radioactive tailings waste are generated at the SA Olympic Dam uranium mine per year to produce enough uranium for 25 power reactors, which equates to 400,000 tonnes of tailings waste per reactor per year. That equates to approx. 230,000 cubic metres or 1,050 million (1.05 billion) Coke cans of tailings waste … just to produce enough uranium for one reactor for one year. (The volume of one Coke can is 380 cubic centimetres or 0.00038 cubic metres (m3).[146])
2. About 170 tonnes of depleted uranium waste at enrichment plants (to supply one reactor for one year). That equates to 34 m3[147] or approx. 89,000 empty Coke cans.
3. 25-30 tonnes of spent nuclear fuel (high-level nuclear waste) per year. The volume is about 10 cubic metres equating to 26,000 empty Coke cans.

Another 300 m3 of low- and intermediate-level waste generated at a conventional 1 GW nuclear power plant per year, according to the International Atomic Energy Agency. This comprises contaminated equipment, liquid waste, etc. Another 790,000 Coke cans.

There are also large and problematic waste streams at nuclear reprocessing plants if the spent fuel is reprocessed (about one-third of spent fuel is reprocessed, the other two-thirds is stored pending disposal). Let's assume the spent fuel is not reprocessed.

Overall, the waste generated across the nuclear fuel cycle to operate a 1 GW reactor for one year equates to a volume of over one billion empty Coke cans per year. Excluding the front-end waste (at uranium mines and enrichment plants), and including only the waste generated at nuclear power plants, 816,000 Coke cans per year. Just the spent nuclear fuel alone requires 26,000 empty Coke cans per year.

For Mr. Dutton's hypothetical 450 MW small modular reactors, for the sake of simplicity let's assume these are based on conventional light-water uranium technology, like the US NuScale design or the UK Rolls-Royce design or Russia's floating plant. And let's ignore complications like plans to use higher-enriched uranium fuel (known as HALEU) in SMRs (resulting in lower volumes of more toxic waste) and let's ignore SMR inefficiencies (resulting in more waste per unit of electricity generated compared to large reactors).

With those assumptions, we can simply scale the figures down from a 1 GW reactor. For a 450 MW SMR (the size contemplated by Rolls-Royce), the volume of waste generated across the nuclear fuel cycle would equate to over 450 million empty Coke cans per year. Excluding front-end waste (at uranium mines and enrichment plants), 367,000 Coke cans per year. Just the spent nuclear fuel alone would require about 11,700 empty Coke cans per year. (Energy Minister Chris Bowen, citing Rolls-Royce, arrives at a similar figure of 12,500.[148])

[146] https://web.physics.ucsb.edu/~lecturedemonstrations/Composer/Pages/36.34.html
[147] https://www.aqua-calc.com/calculate/volume-to-weight
[148] https://x.com/Bowenchris/status/1854043913683943819

5. WATER USE AND IMPACTS ON OTHER WATER USES

First, a definition and some generalisations. Consumption is the net water loss from evaporation and equals the amount of water withdrawn from the source minus the amount returned to the source. With cooling towers (a.k.a. closed-loop cooling), the amount of water withdrawn from the source is similar to consumption. With once-through cooling, withdrawal is vastly greater than consumption. Overall water consumption is greater with cooling towers than with once-through cooling. Generally, cooling towers reduce the impacts on aquatic life but increase water consumption. For coastal sites, the loss (consumption) of water is rarely a problem but the impacts on marine life (and other environmental impacts) can be significant.

Woods gives figures of 1,514 to 2,725 litres of water consumption per megawatt-hour (MWh) for nuclear power reactors.[149] The Nuclear Energy Institute states that consumption is 400 gallons/MWH (1,514 l/MWh) with once-through cooling and 720 gallons/MWH (2,726 l/MWh) with cooling towers.[150]

In 2023, global net nuclear capacity was 377 GW(e) and electricity generation was 2,55 million MWh, or 6.77 million MWh/GW/year.[151] Thus, to operate a standard 1 GW (1,000 MW) reactor for one year consumes 10.2 billion litres of water per year with once-through cooling or 18.5 billion litres of water per year with cooling towers. Daily consumption is 28 million litres of water per day with once-through cooling or 51 million litres of water per year with cooling towers.

A 2009 World Economic Forum (WEF) paper gives a near-identical figure for closed-loop cooling (2,700 l/MWh) − plus 170−570 l/MWh for uranium mining and fuel production, giving a total of 2,870 to 3,270 l/MWh.[152]

The Union of Concerned Scientists gives the following figures for water withdrawal (as opposed to consumption):[153]
* With closed-loop recirculating cooling, water withdrawal ranges from 3,000−9,800 l/MWh (72−235 million litres daily for a 1GW reactor);
* With once through cooling, withdrawal is far greater at 95,000−227,000 l/MWh (2.3−5.4 billion litres daily for a 1 GW reactor; 0.84−1.97 trillion litres annually).

[149] Guy Woods, Australian Commonwealth Department of Parliamentary Services, 2006, 'Water requirements of nuclear power stations', http://efmr.org/files/07rn12.pdf
[150] Nuclear Energy Institute, November 2012, Water Use and Nuclear Power Plants, https://web.archive.org/web/20140131085040/http://www.nei.org/Master-Document-Folder/Backgrounders/Fact-Sheets/Water-Use-and-Nuclear-Power-Plants
[151] https://pris.iaea.org/PRIS/WorldStatistics/WorldTrendinElectricalProduction.aspx
[152] World Economic Forum in partnership with Cambridge Energy Research Associates, 2009, 'Energy Vision Update 2009, Thirsty Energy: Water and Energy in the 21st Century', https://d3n8a8pro7vhmx.cloudfront.net/foe/legacy_url/1868/Water-energy-2009CERA.pdf
[153] Union of Concerned Scientists, July 2013, 'Water-Smart Power: Strengthening the U.S. Electricity System in a Warming World', www.ucsusa.org or http://tinyurl.com/ucs-water

The Nuclear Information and Resource Service notes that a typical once-through cooling system draws into each reactor unit more than one billion gallons (3.8 billion litres) of water daily or 500,000 gallons (1.9 million litres) per minute.[154]

Australian engineer Peter Farley writes:[155]
"A particular issue with nuclear is cooling water, A single 1.1 GW nuclear plant, (the most common size) needs 20-25 GL of water per annum. that is about 7% of the water supply for Melbourne, a fully nuclear system would need 4-5 plants to supply Melbourne so increasing fresh water demand by 30-35%. The plant could be cooled by seawater, but that requires more pumps and much higher maintenance due to fouling and corrosion.
"The nuclear plants at Barrakah each pump 100 tonnes of water per second through their cooling systems and the hot water exiting the plants tends to create dead zones in the sea for 100s of meters around the outlets. Fouling will be much more common here than in Northern countries because higher water temperatures mean much faster growth of marine life."

Comparing water consumption of different energy sources

The World Economic Forum paper provides these comparisons of water consumption:[156]
* Nuclear: 2,870 to 3,270 l/MWh for closed-loop cooling including uranium mining and fuel production
* Coal: 1,220 to 2,270 l/MWh (including mining)
* Gas: 700 to 1,200 l/MWh.

Thus nuclear power is significantly thirstier than coal and far thirstier than gas.

A report prepared by Dr Ian Rose for the Queensland Government states that nuclear power consumes about 25% more water than coal plats per unit of electricity generated.[157] Dr. Rose states:
"Nuclear power stations, even of the latest designs, require more cooling water than the latest coal fired stations because they have lower thermodynamic efficiencies. The efficiencies are lower because the steam in a nuclear plant is designed and operated at lower temperature and pressure than for the latest generation of coal fired plants. The lower temperature and pressure inherent in the nuclear plant design results in less efficient use of the heat from the nuclear reaction, and hence more cooling water is needed per unit of electricity production than coal."

Water consumption per megawatt-hour for solar PV and wind power is near-zero.[158]

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[154] Nuclear Information and Resource Service, 'Licensed to Kill', www.nirs.org/reactorwatch/licensedtokill
[155] https://www.openforum.com.au/is-nuclear-power-a-solution-for-australia/
[156] World Economic Forum in partnership with Cambridge Energy Research Associates, 2009, 'Energy Vision Update 2009, Thirsty Energy: Water and Energy in the 21st Century', https://d3n8a8pro7vhmx.cloudfront.net/foe/legacy_url/1868/Water-energy-2009CERA.pdf
[157] Dr. Ian Rose, ROAM Consulting, paper commissioned by Queensland government, October 26, 2006, https://web.archive.org/web/20070908/www.thepremier.qld.gov.au/library/office/NuclearPowerStation261006.doc
[158] https://iopscience.iop.org/article/10.1088/1748-9326/7/4/045802/meta

Dry cooling

Dry (air/gas) cooling is used in only a handful of operating power reactors worldwide.[159] Four of these – the last remaining gas-cooled reactors in the UK – are due to be shut down by the end of the decade.[160] The UK has closed all 28 of its Magnox gas-cooled reactors and France has closed all of its 10 UNGG gas-cooled reactors.[161] The reason that dry cooling is rarely used is that it decreases operating efficiency and increases costs.[162]

Conclusions

On the basis of worldwide experience, lessons for Australia include the following:
* The enormous cooling requirements for nuclear reactors severely limits non-coastal siting options.
* For coastal sites, the impact on marine life can be severe even during routine operations[163], and nuclear accidents can have devastating impacts (e.g. the devastation of the fishing industry in the Fukushima region of Japan following the 2011 nuclear disaster).
* It is unlikely that dry cooling would be an option for nuclear reactors; and if dry cooling was used, it would worsen nuclear power's already considerable cost disadvantage compared to solar PV and wind power.
* The growth of renewable energy in Australia has been, and will continue to be, dominated by two energy sources with very low water requirements: solar PV and wind power.

6. RELEVANT ENERGY INFRASTRUCTURE CAPABILITY, INCLUDING BROWNFIELD SITES AND TRANSMISSION LINES

6.1 Introduction

Australia has no capacity for uranium conversion (or deconversion), no capacity for uranium enrichment, and no capacity for fuel fabrication.

The introduction of nuclear power to Australia would require the education and training of thousands of nuclear scientists, engineers etc., presumably at taxpayers' expense.

[159] https://en.wikipedia.org/wiki/Gas-cooled_reactor
[160] https://en.wikipedia.org/wiki/Advanced_Gas-cooled_Reactor#Existing_AGR_reactors
[161] https://en.wikipedia.org/wiki/Gas-cooled_reactor
[162] https://australiainstitute.org.au/wp-content/uploads/2020/12/Nuclear-siting-40_10.pdf
[163] http://www.nirs.org/reactorwatch/licensedtokill/LiscencedtoKill.pdf

Repeated claims that the renewable energy transition would require 28,000 kms of new transmission lines by 2030 are not true.[164] The Australian Energy Market Operator's (AEMO) 2024 Integrated System Plan for the National Electricity Market states:[165]
"Both Step Change and Progressive Change scenarios require around 5,000 km of transmission to be delivered over the next decade, about half of which is already underway as committed or anticipated projects. Around 10,000 km is needed by 2050. After the next decade, more capacity is expected from sources such as CER, storage and offshore wind that require less transmission for their connection. Future ISPs will continue to reassess the most cost-effective balance between transmission and the other system elements."

Most or all of the owners of the sites targeted by the federal Coalition for nuclear reactors have no interest in supporting the development of nuclear power or in selling their sites. On the contrary, they are pursuing renewable energy projects and energy storage projects.[166]

6.2 Coal-to-nuclear: Lessons from the US and the UK

Claims that converting coal power plants to nuclear plants will be straightforward and advantageous rest on shaky foundations.

Citing experience in the US, shadow energy minister Ted O'Brien told *The Australian*: "The evidence keeps mounting that a coal-to-nuclear strategy is good for host communities, and especially workers as zero-emissions nuclear plants offer more jobs and higher paying ones."[167]

However, 290 coal power plants closed in the US from 2010 to May 2019[168], and many more have closed since then.[169] Not one of them was replaced by nuclear power. The only three reactor construction projects in the US this century have been on existing nuclear sites: the Vogtle project in Georgia, the V.C. Summer projected in South Carolina, and completion of the Watts Barr-2 project in Tennessee.

The same points apply in the UK: 20 coal or oil power plants have closed since 2012[170], none were replaced with nuclear power, and the only nuclear construction project is on an existing nuclear site.

[164] https://reneweconomy.com.au/divide-and-squander-dutton-wants-seven-nuclear-power-plants-the-first-by-2035/
https://www.smh.com.au/politics/federal/nuclear-debate-is-getting-heated-but-whose-energy-plan-stacks-up-20240624-p5jo45.html
[165] https://aemo.com.au/-/media/files/major-publications/isp/2024/2024-integrated-system-plan-isp.pdf?la=en
[166] https://www.acf.org.au/power-games-assessing-coal-to-nuclear-proposals-in-australia
[167] https://www.theaustralian.com.au/nation/politics/peter-dutton-to-reveal-key-details-of-going-nuclear/news-story/87fc2f81063750adfd93a0c802d7c0e4
[168] https://en.wikipedia.org/wiki/List_of_decommissioned_coal-fired_power_stations_in_the_United_States
[169] https://reneweconomy.com.au/rapid-us-coal-exit-has-lessons-for-australia-as-it-faces-down-fossil-lobby-once-again/
https://www.eia.gov/todayinenergy/detail.php?id=55439
[170] https://www.powerstations.uk/coal-countdown/

Mr. O'Brien has promoted nuclear startup Terrapower's plan to replace coal with nuclear in Kemmerer, Wyoming.[171] But Terrapower is at the very early stages of a long and expensive licensing process[172] for a first-of-a-kind reactor belonging to a class of reactors – sodium-cooled, fast-neutron reactors – with a history of failure.[173] The coal plant near the town of Kemmerer will close in 2025. The projected startup of Terrapower's 'Natrium' reactor has been pushed back from 2028 to 2030 and will likely slip further.

The Wyoming coal-to-nuclear project could easily collapse. David Schlissel from the Institute for Energy Economics and Financial Analysis authored a 2022 analysis of the NuScale reactor project in Idaho and accurately predicted its demise.[174] He predicts trouble in Wyoming: "There's every reason in the world to believe that [the Wyoming project] is going to be a bigger financial disaster."[175]

Ominously, TerraPower CEO and president Chris Levesque recently declined to provide an updated cost estimate for the Wyoming project.[176] In 2020, the estimate was US$1 billion for a 345 MW reactor[177]; in 2022 the estimate was US$4 billion.[178] Even without the inevitable cost increases, the estimate is around A$18 billion / GW. CSIRO's 2024 GenCost report finds that nuclear power is more expensive than firmed renewables even with a capital cost of about half that amount.[179]

6.3 Coal-to-nuclear: The trouble with timelines

"There is every reason to be optimistic about bringing small modular net-zero emission nuclear into the power mix in the 2030s," Peter Dutton claims.[180] However, it would be impossible to introduce nuclear power in Australia by the mid-2030s as discussed in section 1 of this submission. Nuclear power could not be operating in Australia before the mid-2040s, and this creates a major timing problem for those proposing to replace coal power plants with nuclear power. All or nearly all of Australia's remaining coal-fired power plants will be closed by the mid-2040s. Alternative power sources will need to be operating well before nuclear power reactors could possibly replace coal.

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[171] https://www.menziesrc.org/news-feed/embracing-a-coal-to-nuclear-transformation

[172] https://www.publicnow.com/view/EE4C0FABE2F4B1F172AD3F3EFC40BC94D04A107B
https://www.reuters.com/business/energy/us-says-gates-backed-reactor-companys-planned-application-needs-work-2024-03-22/

[173] https://reneweconomy.com.au\nuclear-the-slow-death-of-fast-reactors-21046
https://www.climateandcapitalmedia.com/bill-gates-dumb-climate-idea/

[174] https://ieefa.org/articles/ieefa-us-small-modular-reactor-too-late-too-expensive-too-risky-and-too-uncertain

[175] https://oilcity.news/community/energy-community/2023/11/21/wyoming-nuclear-plant-on-track-despite-industry-setback-developer-says/

[176] https://www.geekwire.com/2024/just-watch-us-gates-backed-terrapower-is-bullish-on-being-the-first-next-gen-nuclear-plant-in-u-s/

[177] https://www.theguardian.com/us-news/2021/jun/03/bill-gates-warren-buffett-new-nuclear-reactor-wyoming-natrium

[178] https://www.geekwire.com/2022/new-day-for-nuclear-power-why-terrapowers-cfo-is-confident-about-the-future-despite-challenges/

[179] https://www.csiro.au/en/research/technology-space/energy/GenCost

[180] https://www.theaustralian.com.au/nation/politics/peter-dutton-vows-to-bring-small-nuclear-reactors-online-in-australia-by-mid2030-if-elected/news-story/eaf9eaf2084916fa118fbeebf2ed72c9

The energy transition is already underway at coal and gas sites in Australia and will be much further advanced before nuclear reactors could possibly begin operating. Just a handful of examples are cited here – there are many more:
* The last SA coal power plant, near Port Augusta, was shut down in 2016 and the region has since become a renewables hub.[181]
* AGL is developing coal and gas power station sites into low-emissions industrial energy hubs.[182]
* Yancoal Australia has published a scoping report[183] for the Stratford Renewable Energy Hub, which proposes to transition the coal mine to a 330 MW solar farm and 3.6 GWh of pumped hydro energy storage at the end of its working life.[184]
* The renewable energy transition is in full swing in the Darling Downs region of Queensland.[185]
* In the Collie region of WA, a large battery is under construction and contracts have been signed to add a second stage battery to help flatten the growing solar duck curve and replace coal.[186]

Economist Prof. John Quiggin notes that, in practice, support for nuclear power in Australia is support for coal.[187] He describes nuclear advocacy in Australia as a dog whistle to climate denialists.[188]

6.4 Costing coal-to-nuclear proposals in Australia

In 2023, the federal Labor government released an energy department estimate that it would cost A$387 billion to replace the 21.3 GW capacity of Australia's retiring coal fleet with around 71 SMRs, each with a capacity of 300 MW.[189] Whether small or large reactors were chosen (or some combination of both), the figure could be much higher.

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[181] https://www.abc.net.au/news/2018-10-05/port-augusta-becomes-australian-renewable-energy-hub/10338812
https://www.energymatters.com.au/renewable-news/port-augustas-solar-and-wind-energy-how-nations-may-transition-away-from-fossil-fuels/
[182] https://www.afr.com/policy/energy-and-climate/household-energy-plan-offers-fix-for-both-sides-of-politics-20240315-p5fcsn
https://reneweconomy.com.au/prohibitive-australias-biggest-energy-consumers-and-producers-say-no-to-nuclear-but-is-coalition-listening/
https://www.brisbanetimes.com.au/business/companies/agl-boss-says-no-to-dutton-s-nuclear-vision-for-coal-power-sites-20240315-p5fct5.html
[183] https://www.stratfordcoal.com.au/content/Document/Stratford%20REH%20-%20Scoping%20Report%20-%20reduced.pdf
[184] https://reneweconomy.com.au/yancoal-proposes-solar-and-12-hour-pumped-hydro-storage-for-hunter-mine-site/Stratford%20coal%20mine.%20Image:%20Yancoal%20Australia
[185] https://www.theguardian.com/australia-news/2024/apr/26/leave-politics-to-the-politicians-why-rural-queensland-is-a-hotbed-of-renewable-energy
[186] https://reneweconomy.com.au/neoens-collie-battery-to-be-australias-biggest-after-winning-new-contract-to-flatten-solar-duck/
[187] https://johnquiggin.com/2018/08/13/coal-and-the-nuclear-lobby/
[188] https://johnquigginblog.substack.com/p/why-nuclear-power-wont-work-in-australia
[189] https://www.theguardian.com/australia-news/2023/sep/18/replacing-australias-retiring-coal-power-stations-with-small-nuclear-reactors-could-cost-387bn-analysis-suggests

For SMRs, the most recent, credible costing is NuScale's estimate of A$31.0 billion / GW. (NuScale's most recent cost estimates were US$9.3 billion (A$14.3 billion) for a 462 MW plant comprising six 77 MW reactors.[190])

For the Vogtle project in the US state of Georgia, the estimate is A$23.8 billion / GW (US$17 billion (A$26.2 billion) per 1.1 GW reactor or US$15.5 billion (A$23.8 billion) / GW).[191]

For the Hinkley Point project in the UK, the estimate is A$27.9 billion / GW. (£23 billion (A$44.7 billion) per 1.6 GW reactor or £14.4 billion (A$27.9 billion) / GW.[192])

The following table uses those figures to estimate the cost of 21.3 GW of nuclear capacity:

	A$ / GW	Cost for 21.3 GW
SMR – NuScale	31.0	A$660 billion
US – Vogtle	23.8	A$507 billion
UK – Hinkley Point	27.9	A$594 billion

This cost would amount to at least half a trillion dollars even without considering the vast costs associated with training nuclear workers; establishing and maintaining a regulatory system; security considerations, long-term nuclear waste management and more.

Moreover, as discussed in section 9 of this submission, 20 GW (or 21.3 GW) of nuclear capacity in 2050 would account for only about 7% of Australia's total electrical generating capacity.

Ted O'Brien cites a US Department of Energy report estimating that leveraging existing infrastructure at coal sites could reduce reactor costs by 30%.[193] In fact the report estimates cost reductions of 15-35% compared to construction on a greenfield site.[194] Would a 30% reduction make nuclear power economically viable in Australia? The following calculations suggest not:

Cost estimates	**A$ / MWh**
Lazard's levelised cost estimate for large reactors (US$142–222 / MWh, A$218-342 / MWh), minus 30%[195]	153-240
CSIRO 2030 estimate for SMRs (A$230–382 / MWh), minus 30%[196]	161-267
CSIRO 2030 estimate for 90% wind and solar with integration costs (energy storage and transmission)[197]	89–128

[190] https://www.powermag.com/novel-uamps-nuscale-smr-nuclear-project-gains-participant-approval-to-proceed-to-next-phase/
[191] https://www.ajc.com/news/psc-raises-georgia-power-rates-passing-most-plant-vogtle-expansion-costs-on-to-customers/6BAIOWM7J5BVHFZ2UN27KYXENA/
[192] https://apnews.com/article/uk-nuclear-plant-hinkley-point-costs-67adc627f0acf130d3ea6c2423e98c4e
[193] https://www.dailytelegraph.com.au/news/queensland/revealed-qld-towns-most-likely-to-get-a-nuclear-power-station/news-story/2113b7ad545d7d06bc8f1b4511a397f0
[194] https://www.energy.gov/ne/articles/could-nations-coal-plant-sites-help-drive-clean-energy-transition
[195] https://www.lazard.com/media/xemfey0k/lazards-lcoeplus-june-2024-_vf.pdf
[196] https://www.csiro.au/-/media/Energy/GenCost/GenCost2023-24Final_20240522.pdf
[197] https://www.csiro.au/-/media/Energy/GenCost/GenCost2023-24Final_20240522.pdf

Even with a speculative 30% cost reduction, nuclear power is still far more expensive than firmed renewables. Nuclear costs for large or small reactors would need to be reduced by more than 50% for nuclear power to compete with firmed renewables. There is no reasonable expectation that this could or would ever occur.

The same conclusion follows from other studies. The two most significant economic modelling studies of Australia's energy options are the Net Zero Australia 2023 analysis (see section 11.9 of this submission) and CSIRO's annual GenCost analyses (see section 11.5 of this submission). Both make extremely generous assumptions about nuclear costs – indeed both assume costs several times lower than real-world experience in the UK and the US – yet nuclear power is still found to be uneconomic in both studies.

6.5 Load following

SMRs cannot load follow because they do not exist. There is a history of load following with large reactors but it is problematic as discussed by Australian engineer Peter Farley:[198]
"A key issue with nuclear is relatively poor load following. Power can be ramped from 50-60% to 100% and back reasonably quickly (hours not second or minutes) but it badly affects their lifetime and economics. Due to the high fixed costs and the effect of cycling on increasing maintenance and shortening life, it can be shown that a nuclear plant running at 60% capacity has twice the lifetime cost of power of the same plant running at 90%.
"Therefore, nuclear plants always need support for fast demand changes. In France and Japan this is provided through hydro and pumped hydro and or export/import. France imports at peak and exports off peak. Japan has 27 GW of pumped hydro for 53 GW of nuclear and it ramped coal and gas plants up and down to minimise load changes on nuclear. The North American method is to limit nuclear power to around 15-20% of supply so that even at minimum demand, all available plants can run at or near capacity.
"In the Australian situation, none of these options work, we can't export, we don't have enough hydro and as minimum grid demand is now starting to drop below 11 GW, the maximum number of 1.1 GW plants that we could keep running at 75%CF [capacity factor] is about 10-12. If two or three of those happened to be offline at once on a high demand day, we suddenly have a full-blown power crisis. Victoria had a power crisis when it lost 1,700 MW of coal, what would happen if it lost 2,200 MW of nuclear.
"In 2015 five out of five Swiss reactors were offline for 10 hours, in October 2017, 21 of 58 French reactors were offline for about six weeks. 40% of Belgian capacity has been offline regularly over the last few years. In June last year, Swiss nuclear power ran for ten days at 13% of normal output at one stage supplying 4.3% of demand vs an average of 42%. Last year for the whole year French nuclear produced 22% less than the year before and 34% less than 2005. In 2018 Belgian nuclear power ran to 80% below normal for eight weeks. How do you replace that – two hundred Snowy IIs?"

[198] https://www.openforum.com.au/is-nuclear-power-a-solution-for-australia/

7. FEDERAL, STATE, TERRITORY AND LOCAL GOVERNMENT LEGAL AND POLICY FRAMEWORKS

A May 2024 briefing by the Parliamentary Library summarises relevant domestic laws relating to nuclear power:[199]

Commonwealth

Nuclear activities are regulated under the Australian Radiation Protection and Nuclear Safety Act 1998 (ARPANS Act) and the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act).

Australian Radiation Protection and Nuclear Safety Act 1998

The ARPANS Act establishes a licensing framework for controlled persons (including a Commonwealth entity or a Commonwealth contractor) in relation to controlled facilities (a nuclear installation, a prescribed radiation facility, or a prescribed legacy site). A nuclear installation includes a nuclear reactor for research or the production of radioactive materials for industrial or medical use, and a radioactive waste storage or disposal facility with an activity that is greater than the activity level prescribed by the Australian Radiation Protection and Nuclear Safety Regulations 2018.

The ARPANS Act allows the CEO of the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) to issue licences for controlled facilities. In issuing a facility licence, the CEO 'must take into account the matters (if any) specified in the regulations, and must also take into account international best practice in relation to radiation protection and nuclear safety'.

However, subsection 10(2) of the Act expressly prohibits the CEO from granting a licence for the construction or operation of any of the following nuclear installations: a nuclear fuel fabrication plant; a nuclear power plant; an enrichment plant; or a reprocessing facility. This prohibition does not appear to apply to a radioactive waste storage or disposal facility.

Environment Protection and Biodiversity Conservation Act 1999

The EPBC Act establishes 9 matters of national environmental significance (MNES) and provides for the assessment and approval of these actions if the action has, will have, or is likely to have a significant impact on the MNES. 'Nuclear actions' are one of the MNES. Where a nuclear action is determined to be a controlled action (that is, one likely to have a significant impact and requiring assessment and approval under the Act), the assessment considers the impact of a nuclear action on the environment generally (including people and communities).

The Act provides that a relevant entity (as set out below) must not take a nuclear action unless a requisite approval has been obtained under Part 9 of the Act or a relevant exception applies:

- *a constitutional corporation, the Commonwealth or Commonwealth agency is prohibited from undertaking a nuclear action that has, will have or is likely to have a significant impact on the environment*

[199] Dr Emily Gibson, 30 May 2024, 'Current prohibitions on nuclear activities in Australia: a quick guide', Science, Technology, Environment and Resources; Law and Bills Digest Sections, https://www.aph.gov.au/About_Parliament/Parliamentary_departments/Parliamentary_Library/Research/Quick_Guides/2023-24/NuclearActivitiesProhibitions

- *a person is prohibited from undertaking a nuclear action that has, will have or is likely to have a significant impact on the environment in some circumstances where the Commonwealth may have jurisdiction.*
- *The Act establishes offences for the taking of nuclear actions in those circumstances.*
- *Similarly, the Act provides that a relevant entity (as set out below) must not take an action (including a nuclear action) unless a requisite approval has been obtained under Part 9 of the Act or a relevant exception applies:*
- *a person must not take a relevant action on Commonwealth land that has, will have or is likely to have a significant impact on the environment*
- *a person must not take a relevant action outside Commonwealth land if the action has, will have or is likely to have a significant impact on the environment on Commonwealth land*
- *the Commonwealth or a Commonwealth agency must not take inside or outside the Australian jurisdiction an action that has, will have or is likely to have a significant impact on the environment inside or outside the Australian jurisdiction.*

The Act establishes offences and civil penalty provisions for the taking of an action in those circumstances.

Subsection 140A(1) prohibits the Minister for the Environment from granting an approval for a nuclear action relating to specified nuclear installations. These installations are a nuclear fuel fabrication plant, a nuclear power plant, an enrichment plant, and a reprocessing facility.

States and territories

States and territories generally regulate nuclear and radiation activities through either the health or the environmental protection portfolios. The relevant legislation provides for the protection of health and safety of people, and the protection of property and the environment, from the harmful effects of radiation by establishing licensing regimes to regulate the possession, use, and transportation of radiation sources and substances. Mining of radioactive materials is regulated through the resources portfolio.

In addition, as outlined below, the states and territories have legislation prohibiting certain nuclear activities or the construction and operation of certain nuclear facilities. Importantly, where permitted, nuclear activities (including mining) would also be subject to assessment and approvals under a range of other legislation, including planning and environmental impact assessment, native title and cultural heritage, and radiation licensing laws at the state or territory and Commonwealth level.

New South Wales

Exploration for uranium has been permitted under the Mining Act 1992 since 2012. However, the mining of uranium is prohibited by the Uranium Mining and Nuclear Facilities (Prohibitions) Act 1986 (NSW Prohibitions Act).

The NSW Prohibitions Act also prohibits the construction and operation of certain nuclear facilities, including uranium enrichment facilities, fabrication and reprocessing plants, nuclear power plants, and storage and waste disposal facilities (other than for the storage and disposal of waste from research or medical purposes, or the relevant radiological licensing Act).

Northern Territory

The Atomic Energy Act 1953 (Cth) provides that the Commonwealth owns all uranium found in the territories. Uranium exploration and mining in the Northern Territory (NT) is regulated under both NT mining laws (the Mineral Titles Act 2010 and the Mining Management Act

2001) and the Atomic Energy Act. The Ranger Uranium Mine operated until 2021 and is now undergoing rehabilitation.

The Nuclear Waste Transport, Storage and Disposal (Prohibition) Act 2004 (NT) prohibits the construction and operation of nuclear waste storage facilities, as well as the transportation of nuclear waste for storage at a nuclear waste storage facility in the NT. Nuclear waste is defined as including waste material from nuclear plants or the conditioning or reprocessing of spent nuclear fuel.

This Act also:

- *prohibits public funds from being expended, granted or advanced to any person for, or for encouraging or financing any activity associated with the development, construction or operation of a nuclear waste storage facility*
- *would require the NT Parliament to hold an inquiry into the likely impact of a nuclear waste storage facility proposed by the Commonwealth on the cultural, environmental and socio economic wellbeing of the territory.*

Queensland

Exploration for and mining of uranium are permitted under the Mineral Resources Act 1989. However, it has been government policy to not grant mining leases for uranium since 2015. The government policy ban extends to the treatment or processing of uranium within the state.

The Nuclear Facilities Prohibition Act 2007, in similar terms to the NSW Prohibitions Act, prohibits the construction and operation of nuclear reactors and other nuclear facilities in the nuclear fuel cycle.

Unlike other state and territory prohibition legislation, the Nuclear Facilities Prohibition Act would require the responsible Queensland Minister to hold a plebiscite to gain the views of the Queensland population if the Minister was satisfied that the Commonwealth Government has taken, or is likely to take, steps to amend a Commonwealth law or exercise a power under a Commonwealth law to facilitate the construction of a prohibited nuclear facility, or if the Commonwealth Government adopts a policy position of supporting or allowing the construction of a prohibited nuclear facility in Queensland.

South Australia

The exploration and mining of radioactive material (including uranium) is permitted in South Australia (SA), subject to approvals under the Mining Act 1971 and the Radiation Protection and Control Act 2021 (RP&C Act). For example, uranium is mined at Olympic Dam, Four Mile and Honeymoon. However, conversion and enrichment activities are prohibited by the RP&C Act.

The Nuclear Waste Storage Facility (Prohibition) Act 2000 prohibits the construction or operation of a nuclear waste storage facility, and the import to SA or transport within SA of nuclear waste for delivery to a nuclear waste storage facility.

The Nuclear Waste Storage Facility (Prohibition) Act prohibits the SA Government from expending public funds to encourage or finance the construction or operation of nuclear waste storage facilities. The Act would also require the SA Parliament to hold an inquiry into the proposed construction or operation of a nuclear waste storage facility in SA authorised under a Commonwealth law.

Tasmania

The exploration and mining of atomic substances (which includes uranium and thorium) is permitted under the Mineral Resources Development Act 1995 (Tas), subject to approval.

Victoria

The Nuclear Activities (Prohibitions) Act 1983 prohibits a range of activities associated with the nuclear fuel cycle, including the exploration and mining of uranium and thorium, and the construction or operation of facilities for the conversion or enrichment of any nuclear material, nuclear reactors and facilities for the storage and disposal of nuclear waste from those prohibited activities.

Western Australia

Exploration for and mining of uranium is permitted under the Mining Act 1978. A state policy ban on mining approvals was overturned in November 2008; however, this was reinstated in June 2017, with a 'no uranium' condition on future mining leases. The ban does not apply to 4 projects that had already been approved by the previous government.

The Nuclear Activities Regulation Act 1978 aims to protect the health and safety of people and the environment from possible harmful effects of nuclear activities, including by regulating the mining and processing of uranium and the equipment used in those processes.

The Nuclear Waste Storage and Transportation (Prohibition) Act 1999 also prohibits the storage, disposal or transportation in Western Australia of certain nuclear waste (including waste from a nuclear plant or nuclear weapons).

Nuclear power was made illegal in Australia under two pieces of legislation introduced under the Howard Coalition Government: the Australian Radiation Protection and Nuclear Safety Act 1998 and the Environment Protection and Biodiversity Conservation Act 1999. Any government seeking to pursue nuclear power would need Senate support not only to repeal existing bans but also to pass other legislation to facilitate the development of nuclear power.

Three of the five states being targeted for nuclear power reactors – Queensland, NSW and Victoria – have legislation banning nuclear power. The federal government might have legal powers to override state/territory laws banning nuclear power, although costly and protracted legal challenges could be anticipated. A federal government attempting to introduce nuclear power would also require the political cooperation of relevant state/territory governments, because of the primary role of state/territory governments in managing energy systems, yet nuclear power is opposed by state governments in all five states targeted for nuclear reactors by the Coalition.[200]

Current and former Coalition MPs, including former prime minister Scott Morrison, have argued that nuclear power would require bipartisan support. This important pre-condition clearly does not exist in Australia. With the possible exception of SA, there is bipartisan opposition to nuclear power in the five states.

In SA, Premier Malinauskas doesn't see nuclear power as an option in SA, stating:
"Every single objective, independent analysis that has looked at this has said nuclear power would make power more expensive in Australia rather than cheaper. Why we would impose that burden on power consumers in our country is completely beyond me."[201]

[200] https://reneweconomy.com.au/coalition-in-a-panic-about-response-to-confused-and-unpopular-nuclear-power-plan/

[201] https://www.thenewdaily.com.au/news/politics/australian-politics/2024/04/05/nuclear-states

The position of the SA Liberal Party on nuclear power is somewhat unclear in the wake of a recent leadership change, and non-responses to questions seeking clarification. Regardless of the level of political support, a nuclear power program in SA would be a poor fit. SA has leapt from 1% renewable electricity supply to 74%[202] over the past 16 years and aims to reach 100% net renewables by 2027.[203] According to the SA government, SA has attracted over A$6 billion investment in large-scale renewable energy and storage projects to date with over A$20 billion in the investment pipeline.[204] As noted in section 6.3 of this submission, the last SA coal power plant, near Port Augusta, was shut down in 2016 and the region has since become a renewables hub. A coal-to-nuclear plan in SA could only be a renewables-to-nuclear plan.

SA transmission company ElectraNet says the switch to renewables has led to unprecedented inquiries from energy intensive industries to set up in the state.[205] ElectraNet CEO Simon Emms said in a recent planning document: “As we enter the next phase of the energy transformation, South Australia is now seeing a level of interest from new, large electricity loads not seen for a very long time.”[206]

Liberal/LNP leaders in Victoria, Queensland, WA and NSW do not support the federal Coalition’s nuclear power plants:
* Victorian Liberal leader John Pesutto says he does not support building a nuclear power station in the Latrobe Valley.[207] Shadow energy minister David Davis says “the Victorian Liberals and Nationals support a commonsense transition to renewables that ensures affordability and security of supply”.[208]
* Queensland LNP leader David Crisafulli says the state LNP does not support Peter Dutton’s push for nuclear power.[209] Shadow environment minister Sam O'Connor has publicly guaranteed that nuclear power will not be a part of the LNP's energy transformation plan.[210]
* Whilst supportive of uranium mining, WA Liberal opposition leader Libby Mettam says she has made it clear to her federal colleagues that nuclear power does not stack up in WA.[211]
* NSW opposition leader Mark Speakman has been more circumspect, saying he is awaiting the details of the coal-to-nuclear proposal and that “at the end of the day we have to have energy sources that are clean, cheap and reliable”.[212] He says the NSW Liberal Party remains committed to “achieving net zero emissions by 2050, with interim targets” and that “while

[202] https://www.energymining.sa.gov.au/industry/modern-energy/leading-the-green-economy
[203] https://www.adelaidenow.com.au/news/south-australia/mali-says-sa-uranium-has-a-role-to-play-in-decarbonising-the-world-but-not-in-an-australian-reactor/news-story/8fe7cf7060324ed8cb1f0775e6ff2d8d
[204] https://www.energymining.sa.gov.au/industry/modern-energy/leading-the-green-economy
[205] https://reneweconomy.com.au/blackouts-and-brownouts-the-ideology-behind-coalitions-dystopian-take-on-renewables/
[206] https://reneweconomy.com.au/south-australias-world-leading-renewable-transition-is-attracting-flood-of-new-industry/
[207] https://www.brisbanetimes.com.au/politics/federal/not-in-my-backyard-liberals-nationals-go-cold-on-nuclear-20240322-p5feko.html
[208] https://amp.theguardian.com/australia-news/2024/mar/24/peter-dutton-liberal-leaders-nuclear-power-ban
[209] https://amp.theguardian.com/australia-news/2024/mar/24/peter-dutton-liberal-leaders-nuclear-power-ban
[210] https://www.queenslandconservation.org.au/queensland_lnp_rules_out_nuclear
[211] https://amp.theguardian.com/australia-news/2024/mar/24/peter-dutton-liberal-leaders-nuclear-power-ban
[212] https://www.brisbanetimes.com.au/politics/federal/not-in-my-backyard-liberals-nationals-go-cold-on-nuclear-20240322-p5feko.html

other technologies could be important, renewables will play the major role in achieving this."[213] Mr. Speakman said in April 2024: "We can't wait for nuclear, so in the meantime, here in NSW, we should be going ahead with our electricity road map, which will have heavy reliance on renewables."

There is significant dissent and even cynicism among current and former Coalition MPs about the coal-to-nuclear push:
* Former NSW Liberal MP and former deputy premier Matt Kean states: "I not only regard advocacy for nuclear power as against the public interest on environmental, engineering and economic grounds, I also see it as an attempt to delay and defer responsible and decisive action on climate change in a way that seems to drive up power prices in NSW by delaying renewables."[214]
* Former Liberal Prime Minister Malcolm Turnbull says nuclear power's only utility is as "a means of supporting fossil fuels by delaying and distracting the rollout of renewables" and that nuclear power "is exactly what you don't need to firm renewables."[215]
* Former Liberal leader John Hewson says Dutton may be promoting nuclear "on behalf of large fossil-fuel donors knowing nuclear power will end up being too expensive and take too long to implement, thereby extending Australia's reliance on coal and natural gas".[216]
* Liberal MP Bridget Archer says nuclear power should be pursued only if coupled with a rapid surge in renewables and nuclear power should not be used as an excuse to prolong reliance on fossil fuels.[217] "There is no point even having a nuclear discussion if you don't accept a need to decarbonise, to transition away from coal and gas," she said.[218]

The Dutton Coalition has made it clear that a Coalition government would be prepared to override not only state governments but also local community opposition.[219]

[213] https://www.theguardian.com/australia-news/2023/nov/24/nsw-liberal-leader-mark-speakman-cronulla-branch-windfarms-opposition
[214] https://twitter.com/Matt_KeanMP/status/1775817087606575276
[215] https://www.afr.com/policy/energy-and-climate/inside-the-coalition-s-nuclear-crusade-at-cop28-20231210-p5eqbt
[216] https://www.thesaturdaypaper.com.au/comment/topic/2024/03/06/renewables-deniers-and-the-nuclear-mirage
[217] https://www.smh.com.au/politics/federal/liberal-mp-warns-dutton-on-nuclear-energy-as-labor-steps-up-attacks-20240326-p5ff92.html
[218] https://www.smh.com.au/politics/federal/liberal-mp-warns-dutton-on-nuclear-energy-as-labor-steps-up-attacks-20240326-p5ff92.html
[219] https://johnmenadue.com/duttons-nuclear-thuggery/

8. RISK MANAGEMENT FOR NATURAL DISASTERS OR ANY OTHER SAFETY CONCERNS

8.1 Introduction / ionising radiation
8.2 Childhood leukaemia
8.3 Death toll from the Chernobyl and Fukushima disasters
8.4 Insuring against nuclear accidents
8.5 Inadequate regulation
8.6 Nuclear security
8.7 SMR safety issues

8.1 Introduction / ionising radiation

For further information on the issues discussed here 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:[220]
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

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

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."[221]
- The 2006 report of the US National Academy of Sciences' Committee on the Biological Effects of Ionising Radiation (BEIR) states that "the risk of cancer proceeds in a linear fashion at lower doses without a threshold and … the smallest dose has the potential to cause a small increase in risk to humans."[222]
- The US Nuclear Regulatory Commission (NRC) noted in a 2021 report that "[c]onvincing evidence has not yet demonstrated the existence of a threshold below which there would be no stochastic effects from exposure to low radiation doses."[223] The NRC report further notes that "authoritative scientific advisory bodies" such as the National Academy of Sciences, National Council on Radiation Protection and Measurements, International Commission on Radiological Protection and the International Atomic Energy Agency "support the continued use of the LNT [linear no-threshold] model." The NRC report further noted that three federal agencies – the National Cancer Institute, the National Institute for Occupational Safety and Health, and the EPA's Radiation Protection Division – supported the continued use of the LNT model as the basis for the NRC's radiation protection program.

Whether the relationship between radiation dose and health effects is linear at low doses (and low dose rates) 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."[224]

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 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."[225] The BEIR report also

[221] 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
[222] 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
[223] https://www.regulations.gov/document/NRC-2015-0057-0671
[224] 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
[225] 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

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."

The INWORKS (ionising radiation in workers) studies followed a cohort of "309,932 workers with individual monitoring data for external exposure to ionising radiation" in France, the UK and the US. They concluded: "The summary estimate of excess relative rate solid cancer mortality per Gy is larger than estimates currently informing radiation protection, and some evidence suggests a steeper slope for the dose-response association in the low dose range than over the full dose range."[226] While the study supports a "linear association between protracted low dose external exposure to ionising radiation and solid cancer mortality" (the standard view accepted by the International Commission on Radiological Protection[227]), there is some evidence that effects of radiation exposure could be proportionally larger for lower doses.

8.2 Childhood leukaemia

Radiation biologist Dr. Ian Fairlie, who served as the scientific secretary to the British Government's Commission for Investigation of Radiation Risks of Internal Emitters, notes that 60 epidemiological studies have examined cancer incidence in children near nuclear power plants, that over 70 percent of those studies found increased leukemia incidence, and he concludes that the matter "is now beyond question, i.e. there's a very clear association between increased child leukemias and proximity to NPPs [nuclear power plants]."[228]

Dr Fairlie states:[229]
"My explanation has five main elements. First, the cancer increases may be due to radiation exposures from NPP emissions to air. Second, large annual spikes in NPP emissions may result in increased dose rates to populations within 5 km of NPPs. Third, the observed cancers may arise in utero in pregnant women. Fourth, both the doses and their risks to embryos and to fetuses may be greater than current estimates. And fifth, pre-natal blood-forming cells in bone marrow may be unusually radiosensitive. Together these five factors offer a possible explanation for the discrepancy between estimated radiation doses from NPP releases and the risks observed by the KIKK study.
"My article in fact shows that the current discrepancy can be explained. The leukemia increases observed by KiKK and by many other studies may arise in utero as a result of embryonal/fetal exposures to incorporated radionuclides from NPP radioactive emissions. Very large emission spikes from NPPs might produce a pre-leukemic clone, and after birth a second radiation hit might transform a few of these clones into full-blown leukemia cells. The

[226] David B Richardson et al, 'Cancer mortality after low dose exposure to ionising radiation in workers in France, the United Kingdom, and the United States (INWORKS): cohort study', The BMJ, 16 August 2023 https://www.bmj.com/content/bmj/382/bmj-2022-074520.full.pdf
[227] International Commission on Radiological Protection, ICRP Publication 99: Low-dose Extrapolation of Radiation-related Cancer Risk, 2005 https://www.icrp.org/publication.asp?id=ICRP%20Publication%2099
[228] https://www.ianfairlie.org/news/childhood-leukemias-near-nuclear-power-stations-new-article/
[229] https://www.ianfairlie.org/news/childhood-leukemias-near-nuclear-power-stations-new-article/

affected babies are born pre-leukemic (which is invisible) and the full leukemias are only diagnosed within the first few years after birth."

8.3 Death toll from the Chernobyl and Fukushima disasters

Dr. Ziggy Switkowski notes that the introduction of nuclear power to Australia would risk the "non-negligible" risk of a "catastrophic failing within a nuclear system".[230]

Claims that the Chernobyl death toll was <100 have no basis in scientific evidence. The World Health Organization estimates around 9,000 cancer deaths:[231]
* up to 4,000 additional cancer deaths among the three highest exposed groups over their lifetime (240,000 liquidators; 116,000 evacuees and the 270,000 residents of the 'strictly controlled zones')
* up to 5,000 additional cancer deaths in Belarus, the Russian Federation and Ukraine
* "Chernobyl may also cause cancers in Europe outside Belarus, the Russian Federation and Ukraine."

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.[232]

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 leukemia for males exposed as infants; and for thyroid cancer among females exposed as infants, an increased risk of up to 70% (from a 0.75% lifetime risk up to 1.25%).[233]

Using collective dose estimates very similar to the World Health Organization, radiation biologist Dr. Ian Fairlie estimates around 5,000 cancer deaths from exposure to radiation from the Fukushima disaster.[234]

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[230] https://parlinfo.aph.gov.au/parlInfo/search/display/display.w3p;db=COMMITTEES;id=committees%2Fcommrep%2F3abfb90c-9215-4b65-a5d2-32d112e8cd46%2F0001;query=Id%3A%22committees%2Fcommrep%2F3abfb90c-9215-4b65-a5d2-32d112e8cd46%2F0000%22

[231] World Health Organization, April 2006, 'Health effects of the Chernobyl accident: an overview', https://www.who.int/docs/default-source/documents/publications/health-effects-of-the-chernobyl-accident.pdf

[232] 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, https://pubmed.ncbi.nlm.nih.gov/16628547/, https://onlinelibrary.wiley.com/doi/abs/10.1002/ijc.22037

[233] WHO, 28 Feb 2013, 'Global report on Fukushima nuclear accident details health risks', https://www.who.int/news/item/28-02-2013-global-report-on-fukushima-nuclear-accident-details-health-risks

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

The environmental and human impacts of the Fukushima disaster have been profound, particularly for the more than 190,000 evacuees displaced by the nuclear disaster.[235] Direct economics costs amount to many hundreds of billion dollars[236]; if indirect economic impacts are included, this figure rises to over one trillion dollars.[237] Likewise, Chernobyl was a trillion-dollar accident.[238]

8.4 Insuring against nuclear accidents

Insurance policies from some of Australia's major insurers, including AAMI, CGU, Allianz, QBE and NRMA contain specific text excluding coverage for nuclear disasters.[239] None of these will insure homes, cars or possessions against a nuclear accident or release.

8.5 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.[240] 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[241], India[242], Russia[243], the US[244], Japan[245], South Korea[246] and Ukraine.[247]

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[235] https://www.scientificamerican.com/article/fukushima-residents-return-despite-radiation/
[236] https://www.jcer.or.jp/english/accident-cleanup-costs-rising-to-35-80-trillion-yen-in-40-years
[237] https://web.archive.org/web/20180319194343/https://www.wiseinternational.org/nuclear-monitor/836/economic-impacts-fukushima-disaster
[238] https://globalhealth.usc.edu/wp-content/uploads/2016/01/2016_chernobyl_costs_report.pdf
[239] https://australiainstitute.org.au/post/nuclear-power-uninsurable-and-uneconomic-in-australia/
[240] Nuclear Monitor #800, 19 March 2015, 'Japan's 'nuclear village' reasserting control', www.wiseinternational.org/nuclear-monitor/800/japans-nuclear-village-reasserting-control
[241] 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
[242] 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
[243] Vladimir Slivyak, 2014, 'Russian Nuclear Industry Overview', https://ecdru.files.wordpress.com/2017/04/russian-nuc-ind-overviewrgb.pdf
[244] 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
[245] Nuclear Monitor #800, 19 March 2015, 'Japan's 'nuclear village' reasserting control', www.wiseinternational.org/nuclear-monitor/800/japans-nuclear-village-reasserting-control
[246] Nuclear Monitor #844, 25 May 2017, 'South Korea's 'nuclear mafia'', www.wiseinternational.org/nuclear-monitor/844/south-koreas-nuclear-mafia
[247] 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/

8.6 Nuclear security

Security risks associated with civil nuclear programs include:

- 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[248]).

These issues are addressed in detail in a 2023 joint environment groups' submission to the Senate Environment and Communications Legislation Committee.[249]

The conflict in Ukraine reminds us of the security issues that Australians would need to consider if nuclear power were to be introduced here. The Russian military's seizure of the Zaporizhzhia nuclear power plant – at a time when some of the plant's six reactors were operating – was the most dangerous incident so far. Off-site power to the Zaporizhzhia plant has been cut eight times since Russia seized control of the plant in 2022, increasing the risk of a major accident.[250] International Atomic Energy Agency (IAEA) Director General Rafael Mariano Grossi warned in April 2024 that attacks on the Zaporizhzhia nuclear plant raised "the very real threat of a serious nuclear accident, which could have significant health and environmental consequences and benefit absolutely no one". No other energy system is as easily weaponised as nuclear power and reactors have been described as pre-deployed terrorist targets.

Australian nuclear security issues

Security incidents at ANSTO's Lucas Heights site in southern Sydney include the following[251]:

- 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.

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

[248] 27 March 2000, 'Sabotage inquiry at Sellafield under way', www.irishtimes.com/news/sabotage-inquiry-at-sellafield-under-way-1.260139

[249] https://www.aph.gov.au/DocumentStore.ashx?id=e6d63b51-45cb-4720-a27b-9dab61f2fe66&subId=732042

[250] https://www.iaea.org/newscenter/pressreleases/update-221-iaea-director-general-statement-on-situation-in-ukraine

[251] Tilman Ruff, 2006, 'Nuclear Terrorism', EnergyScience Coalition Briefing Paper #10, www.energyscience.org.au/FS10%20Nuclear%20Terrorism.pdf

- 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."[252]
- 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.[253]

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

8.7 SMR safety issues

Claims about the safety of small modular reactors (SMRs) are untested and untestable since no SMRs exist (see section 1.3 of this submission). SMR safety claims are challenged by experts such as Dr. Edwin Ed Lyman (Union of Concerned Scientists):[254]

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[252] Jonathan Porter, 19 Nov 2005, 'Nuclear site left exposed at the back door', The Australian.

[253] 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

[254] Ed Lyman, 'Five Things the "Nuclear Bros" Don't Want You to Know About Small Modular Reactors', Union of Concerned Scientists, 30 April 2024
https://blog.ucsusa.org/edwin-lyman/five-things-the-nuclear-bros-dont-want-you-to-know-about-small-modular-reactors/
See also:
Ed Lyman, "Advanced" Isn't Always Better: Assessing the Safety, Security, and Environmental Impacts of Non-Light-Water Nuclear Reactors, Union of Concerned Scientists, 18 March 2021
https://www.ucsusa.org/resources/advanced-isnt-always-better
Ed Lyman, Small Isn't Always Beautiful: Safety, Security, and Cost Concerns about Small Modular Reactors, Union of Concerned Scientists, September 2013

"[T]he so-called passive safety features that SMR proponents like to cite may not always work, especially during extreme events such as large earthquakes, major flooding, or wildfires that can degrade the environmental conditions under which they are designed to operate. And in some cases, passive features can actually make accidents worse … In any event, regulators are loosening safety and security requirements for SMRs in ways which could cancel out any safety benefits from passive features … It is also considering further changes that could allow SMRs to reduce the numbers of armed security personnel to protect them from terrorist attacks and highly trained operators to run them. Reducing security at SMRs is particularly worrisome, because even the safest reactors could effectively become dangerous radiological weapons if they are sabotaged by skilled attackers … Considering the cumulative impact of all these changes, SMRs could be as—or even more—dangerous than large reactors."

Dr. Lyman goes on to note that safety margins are being sacrificed in the hope of making SMRs economically competitive:[255]
"Another way that SMR developers try to reduce capital cost is by reducing or eliminating many of the safety features required for operating reactors that provide multiple layers of protection, such as a robust, reinforced concrete containment structure, motor-driven emergency pumps, and rigorous quality assurance standards for backup safety equipment such as power supplies. But these changes so far haven't had much of an impact on the overall cost…"

Dr. Lyman has also commented specifically on safety issues related to the NuScale design:[256]
"As discussed in detail in my September 2013 report "Small Isn't Always Beautiful,"[257] 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 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.

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https://www.ucsusa.org/sites/default/files/2019-10/small-isnt-always-beautiful.pdf

[255] Ed Lyman 2024 op. cit.

[256] 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

[257] 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

"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"[258] (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."

To give another example of disingenuous SMR safety hype from nuclear proponents, non-existent 'integral fast reactors' (IFR) are said to be meltdown-proof in addition to their other purported benefits. The best-known variant of the non-existent IFR is the non-existent Power Reactor Innovative Small Module (PRISM). Once again Dr. Edwin Lyman provides a reality check in an article discussing the *Pandora's Promise* propaganda film:[259]
"In the IFR concept, which was never actually realized in practice, reactor-spent fuel would be reprocessed using a technology called pyroprocessing, and the extracted plutonium would be fabricated into new fuel. IFR advocates have long asserted that pyroprocessing is not a proliferation risk because the plutonium it separates is not completely purified.
"But a 2008 U.S. Department of Energy review – which confirmed many previous studies – concluded that pyroprocessing and similar technologies would "greatly reduce barriers to theft, misuse or further processing, even without separation of pure plutonium."

[258] 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
[259] Edwin Lyman, 7 Nov 2013, 'Scientist: Film hypes the promise of advanced nuclear technology', https://edition.cnn.com/2013/11/07/opinion/lyman-nuclear-pandora/index.html
Edwin Lyman, 7 Nov 2013, 'Scientist: Film hypes the promise of advanced nuclear technology', https://edition.cnn.com/2013/11/07/opinion/lyman-nuclear-pandora/index.html

"Other Department of Energy studies showed that pyroprocessing, by generating large quantities of low-level nuclear waste and contaminated uranium, greatly increases the volume of nuclear waste requiring disposal, contradicting "Pandora's Promise's" claim it would reduce the amount of waste.
"And what about [Charles] Till's claim that the IFR can't melt down? It's false. "Pandora's Promise" referenced two successful safety tests conducted in 1986 at a small demonstration fast reactor in Idaho called the Experimental Breeder Reactor-II (EBR-II). But EBR-II operators scripted these tests to ensure the desired outcome, a luxury not available in the real world. Meanwhile, the EBR-II's predecessor, the EBR-I, had a partial fuel meltdown in 1955, and a similar reactor, Fermi 1 near Detroit, had a partial fuel meltdown in 1966.
"Moreover, fast reactors have inherent instabilities that make them far more dangerous than light-water reactors under certain accident conditions, conditions that were studiously avoided in the 1986 dog-and-pony show at EBR-II."

As another example of questionable SMR safety claims, molten salt reactor (MSR) enthusiasts claim that MSRs are meltdown-proof. MSRs are in fact meltdown-proof, twice over. First, fuel meltdown in MSRs is impossible because MSRs don't exist. Secondly, if MSRs did exist, the fuel couldn't possibly melt because it is liquid. As with solid-fueled reactors, dispersal of radionuclides via fire or chemical explosion is possible … but fuel melting is not. That is not an advantage of MSRs; it could be a liability. The UK National Nuclear Laboratory noted in a 2016 report that constructing a safety case for MSRs will necessarily be very different compared to a conventional reactor:[260]
"This is dictated by the fact that in an MSR the normal operating condition is with the fuel melted and therefore some of the barriers to release of fission products, actinides and activation products in a solid fuel reactor no longer apply. Although MSR designs are typically characterised by strong negative temperature feedback coefficients, un-pressurised systems, tolerance of high temperatures and passive decay heat removal, these features per se may not necessarily make the safety case easy to demonstrate. There will need to be extensive experimental test data available that will substantiate all aspects of the safety case. At present this database does not exist …"

9. POTENTIAL SHARE OF TOTAL ENERGY SYSTEM MIX

It is unclear how many nuclear reactors a Coalition government would build, if any. All that is currently known is that the Coalition's plan envisages one or more reactors at each of seven sites, with large reactors in three eastern states and SMRs in SA and WA. We could guess that total capacity might be in the range of 6–20 gigawatts (GW) of nuclear capacity by 2050. The lower figure (6 GW) might be comprised of 1.1-GW reactors at each of the five selected sites in the eastern states, one 300-MW SMR in SA and one 300-MW SMR in WA. The upper figure (20 GW) assumes that nuclear power replaces almost all of Australia's

[260] National Nuclear Laboratory, 15 March 2016, 'SMR Techno-Economic Assessment, Project 3: SMRs Emerging Technology, Assessment of Emerging SMR Technologies, Summary Report For The Department of Energy and Climate Change', https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/665274/TEA_Project_3_-_Assessment_of_Emerging_SMR_Technologies.pdf

current coal generating capacity (21.3 GW). For the purposes of this brief discussion, we leave aside the impossibility of building 20 GW of nuclear capacity in Australia by 2050.

The Australian Energy Market Operator's (AEMO) 2024 Integrated System Plan for the National Electricity Market envisages electricity generating capacity nearing 300 GW by mid-century in a 'step change' scenario.[261] Thus, 6–20 GW of nuclear capacity would amount to 2–7% of total capacity for the National Electricity Market but possibly a greater percentage of electricity generation (typically measured in terawatt-hours) depending on a range of factors such as whether household rooftop solar is curtailed to allow for uninterrupted operation of nuclear reactors. To put the 6–20 GW figure in perspective, in AEMO's step change scenario, the total capacity of utility-scale wind and solar is forecast to increase six-fold by 2050 from 21 GW currently to 127 GW; and in addition, the capacity of rooftop solar and other distributed solar is forecast to rise from 21 GW to 86 GW.

The above comments refer to electricity; 6–20 GW of nuclear capacity would account for a much smaller percentage of total energy demand than estimates provided above which refer only to electricity.

10. NECESSARY LAND ACQUISITION. ENERGY INDUSTRY OPPOSITION

According to energy minister Chris Bowen, six of the owners of the seven sites targeted for nuclear power reactors by the Coalition have ruled out agreeing to nuclear power reactors on their land.[262]

The Coalition states that it has legal advice that it can use compulsory acquisition powers to seize land for its proposed nuclear reactors. Opposition leader Peter Dutton said: "We will work with the companies, the owners of the sites. If we find a situation where we apply a national interest test and we require that site to be part of the national grid, then the legal advice that we have is that the Commonwealth has ample power to compulsorily acquire that with ample compensation."[263]

Australia's major energy utilities are sceptical about prospects for a nuclear-powered future. *Guardian Australia* reported on 19 March 2024 that Australia's big private electricity generators – AGL Energy, Alinta[264], EnergyAustralia[265] and Origin Energy – have dismissed nuclear energy as a viable source of power for their customers for at least a decade.[266] Instead they say they will remain focused on developing renewable sources as coal and gas

[261] https://aemo.com.au/-/media/files/major-publications/isp/2024/2024-integrated-system-plan-isp.pdf?la=en
[262] https://x.com/Bowenchris/status/1803337819953528887
[263] https://www.abc.net.au/news/2024-06-19/federal-politics-live-blog-peter-dutton-nuclear/103995282
[264] https://reneweconomy.com.au/alinta-boss-compares-nuclear-to-unicorns-in-the-garden-but-warns-of-cost-issues-in-race-to-net-zero/
[265] https://www.smh.com.au/business/companies/energy-giant-sees-hydrogen-outshining-nuclear-in-race-to-replace-coal-20240331-p5fgcw.html
[266] https://www.theguardian.com/australia-news/2024/mar/19/australias-big-electricity-generators-say-nuclear-not-viable-for-at-least-a-decade

plants exit the grid (some of these projects and plans are outlined in section 6.3 of this submission). One senior executive told *The Guardian* power bills would triple if the nuclear path was pursued.[267]

AGL chief executive Damien Nicks warns the nuclear debate risks derailing critical investment in the energy transition.[268] The company reportedly plans 12 GW of new renewable and firming capacity by 2035.[269] Nicks said: "There is no viable schedule for the regulation or development of nuclear energy in Australia, and the cost, build time and public opinion are all prohibitive … AGL is already developing our coal and gas power station sites into low-emissions industrial energy hubs … As the owner of these sites, nuclear energy is not a part of these plans."[270]

Pitching nuclear power in Australia to board rooms and investors is like "looking for unicorns in the garden," Alinta Energy boss Jeff Dimery said in an April 2024 address to the National Press Club.[271]

The Business Council of Australia argues for a rapid, renewables-led decarbonisation.[272] Tennant Reed from the Australian Industry Group says Australia's energy future almost certainly lies in large-scale solar and wind rather than nuclear because solar and wind are cheap, abundant and open doors to developing green export industries.[273]

Rio Tinto says it is not interested in nuclear power and has launched one of the country's biggest ever tenders for wind and solar to repower its Boyne Island and Tomago aluminium smelters and two key refineries, as zinc refiner Sun Metals has done before it.[274]

Former Reserve Bank deputy governor Dr. Guy Debelle says the economic argument against nuclear power "clear at the moment," that introducing SMRs "just doesn't work in any reasonable timeframe" and the costs of large reactors in the US and the UK are "going through the roof."[275]

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[267] https://www.theguardian.com/australia-news/2024/mar/19/australias-big-electricity-generators-say-nuclear-not-viable-for-at-least-a-decade

[268] https://www.afr.com/policy/energy-and-climate/household-energy-plan-offers-fix-for-both-sides-of-politics-20240315-p5fcsn

[269] https://reneweconomy.com.au/prohibitive-australias-biggest-energy-consumers-and-producers-say-no-to-nuclear-but-is-coalition-listening/

[270] https://www.brisbanetimes.com.au/business/companies/agl-boss-says-no-to-dutton-s-nuclear-vision-for-coal-power-sites-20240315-p5fct5.html

[271] https://reneweconomy.com.au/alinta-boss-compares-nuclear-to-unicorns-in-the-garden-but-warns-of-cost-issues-in-race-to-net-zero/#google_vignette

[272] https://d3n8a8pro7vhmx.cloudfront.net/bca/pages/6612/attachments/original/1633693581/BCA_Achieving_a_net_zero_economy_-_9_October_2021.pdf?1633693581

[273] https://www.abc.net.au/news/2024-03-16/nuclear-power-in-australia-silver-bullet-white-elephant/103571824

[274] https://reneweconomy.com.au/prohibitive-australias-biggest-energy-consumers-and-producers-say-no-to-nuclear-but-is-coalition-listening/

[275] https://www.afr.com/policy/energy-and-climate/debelle-rings-alarm-on-green-energy-backlash-20240229-p5f8u6

Kerry Schott, chair of the Energy Security Board, says nuclear power is the most expensive energy option "by far" and that firmed renewables are "by far the cheapest and easiest" option.[276]

A 2024 survey by the Investor Group on Climate Change asked big institutional investors with A$37 trillion under management which energy and climate solutions they believed had good long-term returns.[277] Nuclear power was ranked last of the 14 options.[278] Renewable energy was first. Nuclear power's last placing was due to its "very high cost, and the lack of maturity and deployment in next-generation technologies," the Investor Group said.[279]

Prof. Rod Sims, former chair of the ACCC, states:[280]
"Australia needs the trifecta: lowest cost, reliable and zero-emission electricity. Given that we now have a debate about the merits of two very different zero-emission technologies, renewables versus nuclear, we seem agreed on the need for zero-emission electricity. When we seek lowest cost and reliable electricity, Australia's huge natural advantage of best-in-world solar and wind, combined with a range of technologies to firm these, are clearly the superior option."

Matt Edwards, general manager of Solar Cell Technology at Adani Solar, and a director of the Coalition for Conservation group until he resigned, states:[281]
"The National Party, unfortunately, seeks to agitate rather than to alleviate, amplifying concerns. An "anything-but-renewables" mindset has polluted the LNP, with their "gas-led recovery" failing to ignite, and the remnants of the Coalition now taking an uninspired punt on nuclear, highlighting some recent expectations of minor growth.
"The Nats point out that nuclear might be best placed to replace ailing coal plants. Indeed, given high costs, long lead times and lack of investor appetite for nuclear, it is easy to cynically imagine that these plans might be used to justify extending the life of fossil generation while we wait for an atomic revolution that never comes.
"Faced with losing the race in both cost and convenience, the recalcitrant seek to hobble the winning horses. They tut-tut about imaginary problems with renewables' usage of land and solar waste. Yet another recent study in Nature showed solar waste out to 2050 to be a fraction of that of e-waste from computer and TV sets, and less than a per cent of waste from coal ash. Nuclear is also low waste, though it requires special handling for radioactivity. Meanwhile, solar panel energy density has risen as much as 50 per cent in only a few years, driven by technology advances out of China, Germany, and little old Australia (PERC), punching above its weight."

[276] https://www.afr.com/politics/federal/dutton-s-nuclear-push-could-take-on-political-life-of-its-own-20240313-p5fbzl
[277] https://www.theguardian.com/australia-news/2024/mar/25/climate-conscious-investors-put-nuclear-dead-last-on-list-of-desirable-australian-ventures
[278] https://reneweconomy.com.au/nuclear-ranks-last-on-list-of-good-investments-by-big-institutions/
[279] https://www.brisbanetimes.com.au/business/the-economy/investors-eager-to-power-australia-s-switch-to-renewables-not-nuclear-20240322-p5feha.html
[280] https://www.smh.com.au/environment/climate-change/renewables-v-nuclear-the-facts-point-to-one-clear-winner-20240709-p5js95.html
[281] https://www.afr.com/policy/energy-and-climate/adani-s-started-solar-in-india-so-should-the-nats-in-the-regions-20240220-p5f69l

Jeremy Cooper – Director, Bennelong Funds Management; Chair, Carbon Advisory Board, Future Group; a former Deputy Chair of ASIC and chair of the 2009-10 Super System Review – states:[282]

"If nuclear power does arrive in Australia, it will be an ugly duckling in every possible respect; too late; too costly; too toxic and unable to supply a 21st century power grid that will have moved to flexible power sources. Unlike the famous Danish children's story, the nuclear duckling will never be recognised as a 'swan'.

"This is not to say that the transition to renewable energy is without challenges, costs, and the potential for delays. There are and will be obstacles, but we cannot afford to wait for nuclear energy while continuing to burn fossil fuels in the meantime."

11. COSTS OF DEPLOYING, OPERATING AND MAINTAINING NUCLEAR POWER STATIONS

11.1 Large conventional reactors

A 2019 federal Parliamentary inquiry into domestic nuclear power included Coalition MPs who, in principle, were enthusiastic about nuclear power. However, the Committee's report argued that the government should retain legal bans prohibiting the development of conventional, large nuclear power reactors (Generation I, Generation II and Generation III).[283] Committee chair Ted O'Brien said "Australia should say a definite 'no' to old nuclear technologies."[284] The Committee's report called for a partial repeal of legal bans to permit the development of "new and emerging nuclear technologies", including SMRs. In early 2023, opposition leader Peter Dutton said "I don't support the establishment of big nuclear facilities here at all, I'm opposed to it" and he went on to promote SMRs.[285]

[282] https://reneweconomy.com.au/nuclear-energy-is-an-ugly-duckling-in-every-possible-respect-too-late-too-costly-too-toxic/

[283] https://www.aph.gov.au/Parliamentary_Business/Committees/House/Environment_and_Energy/Nuclearenergy

[284] https://www.adelaidenow.com.au/technology/parliamentary-committee-recommends-lifting-ban-on-modern-nuclear-power-technology/news-story/503887977515479052 11b5a49cf3786f

[285] https://www.peterdutton.com.au/leader-of-the-opposition-transcript-interview-with-tom-crowley-the-daily-aus/

That perspective has been superseded due to the failure of SMRs to advance to commercial deployment and in particular the abandonment of NuScale's flagship project in Idaho. Coalition MPs' promotion of South Korea's construction of large AP1400 reactors in the United Arab Emirates (UAE) suggests the Coalition would support the construction of South Korean AP1400 reactors in Australia and presumably also comparable large reactors such as the Westinghouse AP1000 design or French EPRs (European Pressurised Reactors).

Reactor construction costs have risen dramatically over the past 20 years. Dr. Ziggy Switkowski, who headed the Howard government's 'UMPNER' (Uranium Mining, Processing and Nuclear Power Review) process in 2006, said in 2009 that the construction cost of a 1 gigawatt (GW) power reactor Australia would be A$4–6 billion.[286] Compare that estimate to recent experience in the US, the UK and France:[287]

* **USA**: Construction of two reactors in South Carolina was abandoned after the expenditure of around US$9 billion (A$13.9 billion).[288] The only remaining construction project, two AP1000 reactors in the state of Georgia (known as the Vogtle project), was recently completed at a cost of approx. US$17 billion (A$26.2 billion) per 1.1 GW reactor or US$15.5 billion (A$23.8 billion) / GW.[289]
* **UK**: The cost of the two EPR reactors under construction at Hinkley Point (the only reactors under construction in the UK) has escalated to £23 billion (A$44.7 billion) per reactor or £14.4 billion (A$27.9 billion) / GW.[290]
* **France**: The latest cost estimate for the one and only reactor under construction is €19.1 billion (A$31.0 billion) or €11.9 billion ($A19.4 billion) / GW.[291]

The abandoned V.C. Summer nuclear project in South Carolina. A number of utility and company executives have been charged with crimes – this is known as the 'Nukegate' scandal.[292]

[286] https://www.theaustralian.com.au/opinion/a-clean-and-green-way-to-fuel-the-nation/news-story/92aabe042acb3ef3ffdbdfacc65631bf
[287] https://reneweconomy.com.au/cold-turkeys-the-demise-of-nuclear-power-in-australias-aukus-partner-countries/
[288] https://www.worldnuclearreport.org/Toshiba-Westinghouse-The-End-of-New-build-for-the-Largest-Historic-Nuclear.html
[289] https://www.ajc.com/news/psc-raises-georgia-power-rates-passing-most-plant-vogtle-expansion-costs-on-to-customers/6BAIOWM7J5BVHFZ2UN27KYXENA/
[290] https://apnews.com/article/uk-nuclear-plant-hinkley-point-costs-67adc627f0acf130d3ea6c2423e98c4e
[291] https://www.lemonde.fr/les-decodeurs/article/2024/05/09/les-derapages-de-l-epr-de-flamanville-en-graphiques-le-cout-multiplie-par-six-la-duree-du-chantier-par-quatre_5480745_4355771.html
[292] https://en.wikipedia.org/wiki/Nukegate_scandal

These nuclear cost blowouts confirm the historical pattern identified in a 2014 study which found that 175 out of 180 nuclear power projects exceeded their initial budgets, by an average of 117%.[293]

Clearly Dr. Switkowski's earlier estimate of A$4–6 billion / GW does not reflect the real-world experience in the US (A$23.8 billion / GW), the UK (A$27.9 billion / GW) or France (A$19.4 billion / GW). These three countries also all have long experience with nuclear power, extensive nuclear expertise and synergies across their civil and military nuclear programs, all factors which cannot be said about Australia. Moreover, the above-mentioned reactor construction projects are all on existing nuclear power sites with the advantages that brings, including ready access to infrastructure, transmission, licences, a trained workforce and more.

The 2006 Switkowski report concluded that nuclear power plants in Australia would initially be 10–15% more expensive than in the US because Australia has neither nuclear power construction experience, nor regulatory infrastructure.[294] Applying that 10–15% loading to the cost of 1.1 GW AP1000 reactors in the US (US$17 billion or A$26.2 billion per reactor), a single AP1000 reactor in Australia would cost A$28.8–30.1 billion.

Lazard investment firm's annual reports demonstrate that construction costs and levelised costs for nuclear power are far more expensive than costs for wind and solar, even when energy storage costs are included.[295] (Levelised costs include the costs of both building and operating a plant per unit of electricity generated over the assumed lifetime of the plant. Levelised costs are typically measured in cents per kilowatt-hour or dollars per megawatt-hour.[296]) Lazard's nuclear costs are based on the only project to begin and complete construction in the US this century – the Vogtle project in Georgia, comprising two AP1000 reactors, each with a capacity of 1.1 GW.

These are the construction cost figures from the Lazard 2023 report (construction costs are not included in the 2024 report):[297]

Construction Costs	**US$ / kW (A$ / kW)**
Utility scale solar PV	700–1400 (1077–2154)
Utility scale solar PV plus storage	1075–1600 (1655–2463)
Wind (onshore)	1025–1700 (1578–2617)
Wind (onshore) plus storage	1375–2250 (2117–3464)
Wind (offshore)	3000–5000 (4618–7697)
Nuclear	8475–13,925 (13,046–21,436)

As noted above, the latest estimate for the Vogtle project is US$15.5 billion / GW or US$15,500 (A$23,800) / kW – about 10% higher than the upper end of the range in the Lazard report.

[293] https://www.sciencedirect.com/science/article/abs/pii/S0360544214008925
[294] https://webarchive.nla.gov.au/tep/66043
[295] https://www.lazard.com/media/xemfey0k/lazards-lcoeplus-june-2024-_vf.pdf
[296] https://corporatefinanceinstitute.com/resources/valuation/levelized-cost-of-energy-lcoe/
[297] https://www.lazard.com/media/2ozoovyg/lazards-lcoeplus-april-2023.pdf

These are the levelised cost figures from the Lazard 2024 report:[298]

Levelised Costs	**US$ / MWh (A$ / MWh)**
Utility scale solar PV	29–92 (45–142)
Utility scale solar PV plus storage	60–210 (92–323)
Wind (onshore)	27–72 (42–111)
Wind (onshore) plus storage	45–133 (69–205)
Wind (offshore)	74–139 (114–214)
Nuclear	142–222 (219–342)

Lazard's levelised cost for nuclear power (A$219–342 / MWh) is multiples of the 2006 Switkowski report's estimate of A$40–65 / MWh.[299]

More importantly, the levelised cost for nuclear power is much higher than solar or wind plus storage in Lazard's estimates and several times higher than CSIRO's 2030 Australian estimate of A$89–128 / MWh for 90% wind and solar supply to the National Electricity Market with integration (energy storage and transmission) costs included.[300]

The South Australian Nuclear Fuel Cycle Royal Commission carefully studied nuclear power, including SMRs, and concluded in its 2016 Final Report:[301]
"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."

The Committee has received economic claims that belie reality. For example the 'Nuclear for Climate Australia' group provides an economic analysis based on an overnight capital cost for nuclear power of A$10,000 / kW (equivalent to A$10 billion / GW).[302] That is far lower than real-world costs in the USA (A$23.8 billion / GW), the UK (A$27.9 billion / GW) and France ($A19.4 billion). The group assumes that Australia can build nuclear power reactors at half the cost (or less) of countries with vastly greater experience and expertise. Clearly that is an implausible assumption and thus the economic analysis is worthless.

A 2023 article in *The Conversation* explains a fundamental problem with nuclear economics – its negative learning curve:[303]
"Wright's law states the more a technology is produced, the more its costs decline. Wind and especially solar power and lithium-ion batteries have all experienced astonishing cost declines over the last two decades. For nuclear power, though, Wright's law has been inverted. The more capacity installed, the more costs have increased. Why? This 2020 MIT

[298] https://www.lazard.com/media/xemfey0k/lazards-lcoeplus-june-2024-_vf.pdf
[299] http://pandora.nla.gov.au/tep/66043
[300] https://www.csiro.au/-/media/Energy/GenCost/GenCost2023-24Final_20240522.pdf
[301] https://nuclear.foe.org.au/wp-content/uploads/NFCRC_Final_Report_Web_5MB.pdf
[302] https://nuclearforclimate.com.au/wp-content/uploads/2024/11/House-Select-Committee-on-Nuclear-Energy-NFC.pdf
[303] https://theconversation.com/is-nuclear-the-answer-to-australias-climate-crisis-216891

study found that safety improvements accounted for around 30% of nuclear cost increases, but the lion's share was due to persistent flaws in management, design, and supply chains."

Operating in a high-renewables grid would further worsen nuclear economics. An article co-authored by Steven Hamilton – assistant professor of economics at George Washington University and visiting fellow at the Tax and Transfer Policy Institute at the ANU – outlined:[304]

"Opposition Leader Peter Dutton said: "Labor sees nuclear power as a competitor to renewables. The Coalition sees nuclear power as a companion to renewables.
The trouble is that nuclear is a terrible companion to renewables. The defining characteristic of being "compatible" with renewables is the ability to scale up and down as needed to "firm" renewables.
"Even if we don't build a single new wind farm, in order to replace coal in firming renewables, nuclear would need to operate at around 60 per cent average utilisation (like coal today) to keep capacity in reserve for peak demand. This alone would push the cost of nuclear beyond $225/MWh. To replace gas as well, the cost skyrockets beyond $340/MWh."

11.2 The ever-increasing need for taxpayer subsidies

In 2006, then UK industry secretary Alistair Darling said the private sector would have to "initiate, fund, construct and operate" nuclear power plants. This has not happened in the UK where no construction has occurred or will occur without taxpayer subsidy packages amounting to tens of billions of dollars.[305]

The UK National Audit Office estimates taxpayer subsidies for the Hinkley Point project – primarily in the form of a guaranteed payment of £92.50 (A$180) / MWh (2012 prices), indexed for inflation, for 35 years – could amount to £30 billion (A$58.4 billion) for a plant with a capacity of 3.2 GW.[306] Other credible estimates put the figure as high as £48.3 billion (A$94.0 billion).[307]

South Korean utilities opted out of the Wylfa[308] and Moorside[309] reactor construction projects in the UK (as did Japanese companies Hitachi[310] and Toshiba[311]), despite offers of many billions of dollars of British taxpayer subsidies. Announcing the failure of the Wylfa project in 2019, then UK minister for Business, Energy and Industrial strategy Greg Clark said potential investors including South Korean companies were offered a "generous package of

[304] https://www.brisbanetimes.com.au/politics/federal/nuclear-is-ok-if-it-makes-economic-sense-but-mr-dutton-in-australia-it-doesn-t-20240317-p5fd1s.html
[305] https://www.theguardian.com/environment/2016/jul/28/hinkley-point-c-timeline-all-the-key-moments
[306] https://www.theguardian.com/uk-news/2016/jul/13/hinkley-point-c-cost-30bn-top-up-payments-nao-report
[307] http://www.no2nuclearpower.org.uk/wp/wp-content/uploads/2017/09/Time-to-Cancel-HinkleyFinal.pdf
[308] https://wiseinternational.org/nuclear-monitor/871/uk-nuclear-new-build-program-collapsing
[309] https://www.wiseinternational.org/nuclear-monitor/869/toshiba-gives-moorside-nuclear-power-project-uk
[310] https://www.theguardian.com/business/2019/jan/17/hitachi-set-to-scrap-16bn-nuclear-project-anglesey-wales
[311] https://www.theguardian.com/environment/2018/nov/08/toshiba-uk-nuclear-power-plant-project-nu-gen-cumbria

potential support that goes beyond what any government has been willing to consider in the past."[312]

Two points are remarkable: the UK government's willingness to offer subsidies that go beyond the extraordinary Hinkley Point subsidies and the fact that potential vendors are declining to pursue nuclear projects even when such massive subsidies are on offer.

The UK government hopes to progress the Sizewell C project in Suffolk, comprising two EPR reactors, and is once again offering very generous support. This includes taking an equity stake in the project and using a 'regulated asset base'[313] model which foists financial risks onto taxpayers and electricity ratepayers and could result in consumers paying billions for failed projects – as it has in the US.[314]

Vast subsidies[315] have been offered to encourage the commercial development of nuclear power reactors in the US, resulting in nothing more than the abandoned V.C. Summer project in South Carolina and the massively over-budget Vogtle project in Georgia. Vast taxpayer subsidies are still on offer in the US but not a single reactor is under construction.

France has abandoned the idea of pursuing nuclear power as a commercial venture. By early 2023 the debt carried by Électricité de France (EDF), the centrepiece of France's nuclear reactor program, had ballooned to €64.5 billion (A$105 billion). EDF was fully nationalised later in 2023 due to its crushing debts.

The demise of nuclear power as a commercial venture was made clear at a Nuclear Energy Summit organised by the International Atomic Energy Agency (IAEA) in Brussels in March 2024. Nuclear industry representatives were "left humbled by the tepid reaction of bankers assessing the price tag of their ambitions," *Bloomberg* reported.[316] "If the bankers are uniformly pessimistic, it's a self-fulfilling prophecy," former US Energy Secretary Ernest Moniz said after listening to a panel of international lenders explain why they are unwilling to provide the US$5 trillion the industry claims it needs by mid-century.[317]

"The project risks, as we have seen in reality, seem to be very high," European Investment Bank Vice President Thomas Ostros told the IAEA conference, and the Bank recommends countries needing power quickly focus on renewables and energy efficiency. The European and US emphasis on private capital "will likely need to change if Western economies want to maintain nuclear's market share," Mr. Ostros said. "We need state involvement, I don't see any other model. Probably we need quite heavy state involvement to make projects bankable."

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[312] https://www.wiseinternational.org/nuclear-monitor/869/toshiba-gives-moorside-nuclear-power-project-uk
[313] https://stopsizewellc.org/rab/
[314] https://thecurrentga.org/2021/10/15/latest-vogtle-deal-may-mean-extra-3-78-month-on-georgia-power-bill-bills/
[315] https://www.taxpayer.net/wp-content/uploads/2021/02/TCS-Nuclear-Report.pdf
[316] https://www.bloomberg.com/news/articles/2024-03-22/filling-nuclear-power-s-5-trillion-hole-is-beyond-the-banks
[317] https://www.bloomberg.com/news/articles/2024-03-22/filling-nuclear-power-s-5-trillion-hole-is-beyond-the-banks

On the basis of recent experience in the UK, the US, France and other countries, Australia should assume the need for extraordinary taxpayer subsidies, likely in the tens of billions of dollars, if a decision was made to pursue nuclear power as a private sector-driven program. Evidently the Coalition has abandoned the idea of such a program and intends to fund nuclear power using taxpayer dollars exclusively.

The pursuit of SMRs could further elevate taxpayer subsidies. A 2018 study published in the *Proceedings of the National Academy of Science* concluded SMRs would not be viable in the US without "several hundred billion dollars of direct and indirect subsidies" over the next several decades "since present competitive energy markets will not induce their development and adoption."[318]

Moreover, the industry would seek to foist most of the costs of major nuclear accidents onto Australian citizens and taxpayers. In the US, this subsidy is provided by the Price-Anderson Act. This legislation provides a damages cap for nuclear utilities facing claims arising from a nuclear accident or incident. Commenting on the recent extension of the Act, Dr. Edwin Lyman from the Union of Concerned Scientists said: "The nuclear industry's push for a 40-year Price-Anderson Act extension is a sure sign that it doesn't believe its own messaging about how safe the next generation of nuclear reactors is going to be."[319]

Closer to home it is noteworthy that insurance policies from some of Australia's major insurers, including AAMI, CGU, Allianz, QBE and NRMA contain specific text excluding coverage for nuclear disasters.[320] None of these will insure homes, cars or possessions against a nuclear accident or release.

To summarise: less than 20 years ago, the UK government was insisting that nuclear power reactors could be built by the private sector without subsidy. Now, the Australian Coalition evidently believes that reactors would not be built by the private sector even with massive subsidies, hence the proposal for a taxpayer-funded nuclear program.

11.3 Small reactors (SMRs)

Far from being a real-world nuclear technology suitable for Australia, SMRs increasingly appear to be a pipedream and expensive commercial failure. An important recent analysis of SMRs by Dr. Edwin Lyman notes that much of the promotion of SMRs is "rooted in misinformation".[321] Dr. Lyman notes that SMRs are not more economical than large reactors; they are not generally safer or more secure than large reactors; they will not reduce the problem of what to do with radioactive waste; they cannot be counted on to provide reliable and resilient off-the-grid power; and they do not use fuel more efficiently than large reactors.

[318] https://www.pnas.org/content/115/28/7184
[319] https://beyondnuclearinternational.org/2024/03/31/nuclear-comes-last/
[320] https://australiainstitute.org.au/post/nuclear-power-uninsurable-and-uneconomic-in-australia/
[321] https://blog.ucsusa.org/edwin-lyman/five-things-the-nuclear-bros-dont-want-you-to-know-about-small-modular-reactors/

A 2024 report by the Institute for Energy Economics and Financial Analysis (IEEFA) presents these key findings:[322]
* Small modular reactors still look to be too expensive, too slow to build, and too risky to play a significant role in transitioning from fossil fuels in the coming 10-15 years.
* Investment in SMRs will take resources away from carbon-free and lower-cost renewable technologies that are available today and can push the transition from fossil fuels forward significantly in the coming 10 years.
* Experience with operating and proposed SMRs shows that the reactors will continue to cost far more and take much longer to build than promised by proponents.
* Regulators, utilities, investors and government officials should embrace the reality that renewables, not SMRs, are the near-term solution to the energy transition.

The IEEFA report goes on to state:[323]
"The rhetoric from small modular reactor (SMR) advocates is loud and persistent: This time will be different because the cost overruns and schedule delays that have plagued large reactor construction projects will not be repeated with the new designs. But the few SMRs that have been built (or have been started) paint a different picture – one that looks startingly similar to the past. Significant construction delays are still the norm and costs have continued to climb.
"IEEFA has taken a close look at the data available from the four SMRs currently in operation or under construction, as well as new information about projected costs from some of the leading SMR developers in the U.S. The results of the analysis show little has changed from our previous work. SMRs still are too expensive, too slow to build, and too risky to play a significant role in transitioning from fossil fuels in the coming 10 to 15 years."

A 2024 report by the Australian Academy of Technological Sciences and Engineering notes that no small modular reactors exist in any OECD countries and the technology has not been proven technically or financially.[324]

Just two SMR plants are said to be operating, although neither of them meets the 'modular' definition of serial factory production of reactor components (as opposed to the usual practice of construction being concentrated at the reactor site). These SMRs – one twin-reactor plant in Russia and another twin-reactor plant in China – exhibit problems familiar in the wider nuclear sector, including massive cost blowouts and multi-year delays.[325]

Importantly, the so-called SMRs in Russia and China were not built using serial factory production methods, nor are there plans to mass produce these reactor types using serial factory production methods. They are not SMRs. They could not even be called prototype

[322] Institute for Energy Economics and Financial Analysis (IEEFA), May 2024, 'Small Modular Reactors: Still too expensive, too slow and too risky', https://ieefa.org/resources/small-modular-reactors-still-too-expensive-too-slow-and-too-risky
[323] Institute for Energy Economics and Financial Analysis (IEEFA), May 2024, 'Small Modular Reactors: Still too expensive, too slow and too risky', https://ieefa.org/resources/small-modular-reactors-still-too-expensive-too-slow-and-too-risky
[324] https://www.atse.org.au/what-we-do/strategic-advice/small-modular-reactors-the-technology-and-australian-context-explained/
[325] https://nuclear.foe.org.au/wp-content/uploads/SMR-BRIEFING-PAPER-FOE-AUSTRALIA-2023.pdf

SMRs. They are simply small reactors. SMRs are best thought of as Smoke & Mirror Reactors: they do not exist.

The construction cost of Russia's floating nuclear power plant (with two 35-MW reactors) increased six-fold from 6 billion Rubles to 37 billion Rubles (A$567 million).[326] The OECD's Nuclear Energy Agency estimates that the electricity it produces costs US$200 (A$308) / MWh, with the high cost due to large staffing requirements, high fuel costs and the resources required to maintain the barge and coastal infrastructure.[327] To put that in perspective, the Minerals Council of Australia states that SMRs won't find a market unless they can produce power at a cost of A$60–80 / MWh – about one-quarter of the cost of electricity produced by the Russian plant.[328]

The cost of electricity produced by the Russian plant also exceeds costs from large reactors – US$142–222 (A$218–342) / MWh, according to the latest report by investment firm Lazard[329] – even though SMRs are being promoted as the solution to the excessive costs of large nuclear plants.

The other operating SMR (loosely defined) is China's demonstration 210 MW high-temperature gas-cooled reactor (HTGR). The World Nuclear Association states that the cost of the demonstration HTGR was US$6,000 (A$9,240) per kW.[330] That is three times higher than a 2009 cost estimate from Tsinghua University researchers, and two to three times higher than the cost-per-kW of China's larger Hualong reactors.[331]

Wang Yingsu, secretary general of the nuclear power branch of the China Electric Power Promotion Council, said in 2021 that HTGRs would never be as cheap as conventional light-water reactors.[332] China dropped plans to manufacture 18–20 HTGRs after levelised cost estimates rose to levels higher than conventional large reactors.[333] There are reports of plans to build a larger 655 MW HTGR plant.[334] However, China's Institute of Nuclear and New Energy Technology at Tsinghua University expects the cost of a 655 MW HTGR will be 15–20% higher than the cost of a conventional 600 MW pressurised water reactor.[335]

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[326] https://www.worldnuclearreport.org/The-World-Nuclear-Industry-Status-Report-2021-HTML.html#_idTextAnchor013

[327] https://www.oecd-nea.org/jcms/pl_14924

[328] https://www.parliament.vic.gov.au/images/stories/committees/SCEP/Inquiry_into_Nuclear_Prohibition_Inquiry_/Transcripts/25_June_2020/5._FINAL_-_Minerals_Council_Aust.pdf

[329] https://www.lazard.com/media/xemfey0k/lazards-lcoeplus-june-2024-_vf.pdf

[330] https://www.world-nuclear.org/information-library/country-profiles/countries-a-f/china-nuclear-power.aspx

[331] https://www.researchgate.net/publication/245194953_Current_status_and_technical_description_of_Chinese_2_250_MW_th_HTR-PM_demonstration_plant

[332] https://www.scmp.com/news/china/science/article/3159945/china-revives-abandoned-htgr-nuclear-technology-safe-power-drive

[333] https://www.nucnet.org/news/progress-and-status-in-the-race-for-commercialisation-2-4-2020
https://www.world-nuclear-news.org/NN-First-vessel-installed-in-Chinas-HTR-PM-unit-2103164.html

[334] https://www.world-nuclear.org/information-library/country-profiles/countries-a-f/china-nuclear-power.aspx

[335] https://www.world-nuclear.org/information-library/country-profiles/countries-a-f/china-nuclear-power.aspx

Three SMRs are under construction – again with the qualification that there's nothing 'modular' about these projects.

The cost estimate for the small reactor under construction in Argentina is US$750 million (A$1.15 billion) for a reactor with a capacity of just 32 MW.[336] That is over one billion Australian dollars for a plant with the capacity of a handful of large wind turbines. In 2004, when the CAREM reactor was in the planning stage, Argentina's Bariloche Atomic Center estimated an overnight cost of US$1,000 / kW for an integrated 300 MW plant – while acknowledging that to achieve such a cost would be a "very difficult task".[337] That estimate is over twenty times lower than the current estimate for the CAREM reactor.

In 2021, China began construction of a 125 MW pressurised water reactor. According to China National Nuclear Corporation, construction costs per kW will be twice the cost of large reactors while levelised costs will be 50% higher than large reactors.[338]

There is no expectation that HTGRs or conventional small reactors in China could compete economically with large reactors. Moreover, large nuclear reactors in China are not competitive with renewables. The cost differential is reflected in the relative growth of nuclear and renewables. In 2023, China's nuclear power program added only 1.2 GW capacity while combined wind and solar added 278 GW.[339]

In 2021, construction of the 300 MW demonstration lead-cooled BREST fast neutron reactor began in Russia. In 2012, the estimated cost for the reactor and associated facilities was 42 billion Rubles[340] but the estimate has more than doubled to 100 billion Rubles (A$1.53 billion).[341]

11.4 Lessons from the NuScale SMR failure

Dozens of SMRs are said to be in the 'planning' stage; in other words, they have little to show except media releases, PowerPoint presentations, and images of what the reactors might look like if they existed. NuScale was closer than any other company to beginning construction of an SMR in the USA, but it spectacularly abandoned its flagship project in Idaho in 2023.[342]

NuScale secured subsidies amounting to around US$4 billion (A$6.2 billion) from the US government but didn't come close to securing sufficient funding from other sources to get the project off the ground.[343]

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[336] https://www.gihub.org/quality-infrastructure-database/case-studies/carem-25-prototype/
[337] https://www.researchgate.net/publication/267579277_CAREM_concept_A_competitive_SMR
[338] https://nucleus.iaea.org/sites/INPRO/df17/IV.1.-DanrongSong-ACP100.pdf
[339] https://cleantechnica.com/2024/01/12/nuclear-continues-to-lag-far-behind-renewables-in-china-deployments/
[340] https://bellona.org/news/nuclear-issues/2015-05-perpetual-search-perpetuum-mobile
[341] https://tass.com/economy/1300401
[342] https://reneweconomy.com.au/coalitions-nuclear-smr-poster-boy-cancels-flagship-project-due-to-soaring-costs/
[343] https://ieefa.org/resources/eye-popping-new-cost-estimates-released-nuscale-small-modular-reactor

NuScale's most recent cost estimates were exorbitant: US$9.3 billion (A$14.3 billion) for a 462 MW plant comprising six 77 MW reactors.[344] That equates to US$20,100 (A$30,900) per kW and a levelised cost of US$89 (A$137) / MWh. Without the Inflation Reduction Act subsidy of US$30/MWh, the figure would be US$119 (A$183) / MWh. That is not far short of the estimate of A$225 / MWh in a report by WSP Parsons Brinckerhoff, commissioned by the 2015/16 South Australian Nuclear Fuel Cycle Royal Commission.[345]

As referenced earlier, the Minerals Council of Australia states that SMRs won't find a market in Australia unless they can produce power at a cost of A$60-80 / MWh.[346] That is about three times less than the WSP Parsons Brinckerhoff estimate and the latest NuScale estimate.

Of course, NuScale's latest estimate does not reflect the inevitable cost increases if an SMR plant is ever constructed, such as the six-fold increase in the cost of Russia's floating nuclear power plant, or the three-fold increase in the cost of China's HTGR.

The likelihood of NuScale actually building any reactors appears to be diminishing by the day. The company is heading towards bankruptcy[347] with a net loss of US$180 million in 2023.[348] It sacked 154 staff[349] in early 2024 and a class action may hasten the company's demise.[350]

US nuclear specialist Linda Pentz Gunter commented on the aftermath of the decision to abandon the Idaho project, stating:[351]
"Five months later, NuScale is "burning cash at the rate of $185 million per year," as reported by Motley Fool. "NuScale's VOYGR nuclear power product has 'no secure customers' and is 'not cost competitive' says one analyst." Three days later the company's CEO, John Hopkins, sold 59,768 of his shares. This is the same CEO who declared NuScale's SMR project, aptly named VOYGR, "a dead horse." It's clearly on a journey to nowhere. "We think investor enthusiasm for SMR is misguided," declared analysts at Wells Fargo."

[344] https://www.powermag.com/novel-uamps-nuscale-smr-nuclear-project-gains-participant-approval-to-proceed-to-next-phase/
[345] http://web.archive.org/web/20230326165107/http:/nuclearrc.sa.gov.au/app/uploads/2016/05/WSP-Parsons-Brinckerhoff-Report.pdf
[346] https://www.parliament.vic.gov.au/images/stories/committees/SCEP/Inquiry_into_Nuclear_Prohibition_Inquiry_/Transcripts/25_June_2020/5._FINAL_-_Minerals_Council_Aust.pdf
[347] https://iceberg-research.com/2023/11/16/the-collapse-of-the-uamps-deal-raises-the-prospect-of-bankruptcy-for-nuscale/
[348] https://www.utilitydive.com/news/nuscale-small-modular-reactor-smr-data-center-nuclear/710442/
[349] https://www.world-nuclear-news.org/Articles/NuScale-cuts-jobs,-refocuses-on-key-strategic-area
[350] https://www.opb.org/article/2023/11/22/nuscale-nuclear-power-lawsuit/
[351] https://beyondnuclearinternational.org/2024/03/31/nuclear-comes-last/

11.5 Independent estimates of SMR costs

CSIRO's *GenCost* 2023–24 report, released in May 2024, provides the following levelised cost estimates (and others), with the nuclear SMR costs based on the NuScale project in the US:[352]

	2023 (A$/MWh)	2030 (A$/MWh)
Nuclear SMR	387–641	230–382
Nuclear – large-scale	155–252	141–233
90% wind and solar supply to the National Electricity Market with integration costs included (energy storage and transmission)	100–143	89–128

SMRs are not cost-competitive with firmed renewables, according to CSIRO's estimates.

Moreover, the GenCost report makes some extraordinary assumptions in favour of nuclear power:
* Its estimate for construction costs for large reactors in Australia is three times lower than the most recent projects in the UK and the US.
* It assumes that SMR costs will come down due to a learning curve. But there are no SMRs in operation, nor any under construction. At best, there are one or two prototype SMRs under construction (such as China's 125 MW pressurised water reactor). None are being built using serial, modular factory construction techniques but there is some slight possibility that such techniques might be used in future (in which case these reactors might be called prototype SMRs). There is no SMR learning curve and no basis for CSIRO's assumption that costs will come down in the foreseeable future let alone by 2030.

A study by WSP Parsons Brinckerhoff, commissioned by the 2015/16 South Australian Nuclear Fuel Cycle Royal Commission, estimated costs of A$180–184 / MWh for large pressurised water reactors and boiling water reactors, and A$198–225 / MWh for SMRs.[353] The two SMR proposals subjected to detailed economic analysis were Generation mPower, which abandoned plans to build SMRs in 2017 and NuScale, which abandoned its flagship project in 2023 and faces an uncertain future.[354]

A 2015 report by the International Energy Agency and the OECD Nuclear Energy Agency predicts electricity costs from SMRs will typically be 50−100% higher than for current large reactors, although it holds out some hope that large volume factory production of SMRs could help reduce costs.[355]

A 2016 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 likely be 30% more expensive than power from large reactors, because of diseconomies of scale and

[352] https://www.csiro.au/en/research/technology-space/energy/GenCost
[353] http://nuclearrc.sa.gov.au/app/uploads/2016/05/WSP-Parsons-Brinckerhoff-Report.pdf
[354] https://wiseinternational.org/nuclear-monitor/872-873/mpower-obituary
[355] https://www.oecd-nea.org/ndd/pubs/2015/7057-proj-costs-electricity-2015.pdf

the costs of deploying first-of-a-kind technology.[356] Keep in mind that the cost estimate for the only two large reactors in the UK is an astronomical A$27.9 billion / GW.

A 2016 European Commission report notes that decommissioning and waste management costs of SMRs "will probably be higher than those of a large reactor (some analyses state that between two and three times higher)."[357]

A 2014 study published in *Energy and Power Engineering* estimated fuel costs for integral pressurised water SMRs to be 15–70% higher than for large light water reactors and points to research indicating similar comparisons for construction costs.[358]

11.6 Non-independent estimates of SMR costs

The Minerals Council of Australia (MCA) claims "robust estimates" using "conservative assumptions" indicate SMRs will produce power at a cost of A$64–77 / MWh by 2030.[359] However, the "robust estimates" using "conservative assumptions" are from companies that haven't built a single SMR between them. Describing estimates provided by sources with a direct interest in a project as "independent" is simply not accurate.

The MCA bolsters its SMR cost claims with reference to the Energy Information Reform Project (EIRP), which purports to have conducted a 'standardized cost analysis of advanced nuclear technologies in commercial development.'[360] In fact, the EIRP study simply collates company estimates and presents them with this qualification: "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."

The MCA, in its submission to the 2019 federal parliamentary nuclear inquiry, claimed SMRs could generate electricity for as little as A$60 / MWh.[361] That claim was based on a report by the Economic and Finance Working Group (EFWG) of the Canadian 'SMR Roadmap' initiative.[362] However, the MCA is selective in its use of the EFWG estimates: among the many estimates it excludes is the C$162.67 (A$179) / MWh estimate for power from a first-of-a-kind 300 MW on-grid SMR or, at the upper end, the estimate of C$894.05 (A$982) / MWh for power from a first-of-a-kind 3 MW remote community SMR.

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356 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

357 https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A52017SC0158&print=true

358 https://www.scirp.org/journal/PaperInformation.aspx?PaperID=45669

359 https://minerals.org.au/wp-content/uploads/2022/12/Small-modular-reactors-in-the-Australian-context_Ben-Heard_2022-update.pdf
For discussion see https://reneweconomy.com.au/small-nuclear-reactors-huge-costs/

360 https://www.innovationreform.org/wp-content/uploads/2018/01/Advanced-Nuclear-Reactors-Cost-Study.pdf

361 https://www.aph.gov.au/DocumentStore.ashx?id=8f16efb2-f05a-43a8-8d7f-a7c61df2fa97&subId=670566

362 https://smrroadmap.ca/wp-content/uploads/2018/12/Economics-Finance-WG.pdf

In April 2024, Rolls-Royce claimed it could build a 470-megawatt reactor in Australia for A$3.5–5 billion, as reported in *The Australian*.[363] That equates to A$7.4-10.6 billion / GW. For comparison, this table compares Rolls-Royce's claim with NuScale's latest SMR cost estimate, with Hinkley Point (the only construction project in the UK), and with the Vogtle project in the US:

Rolls-Royce	A$7.4-10.6 billion / GW
NuScale SMR	A$31.0 billion / GW (US$20.1 billion / GW)
Hinkley Point (UK)	A$27.9 billion / GW (£14.4 billion / GW)
Vogtle (USA)	A$23.8 billion / GW (US$15.5 billion / GW)

It is implausible that Rolls-Royce could build an SMR for as little as one quarter of the cost (per gigawatt) of the NuScale SMR proposal or one third of the cost of large reactor projects in the UK or the US. At this stage, Rolls-Royce does not even have a licensed design, let alone an operating SMR. Its cost claims should be seen in that context. Rolls-Royce's progress with SMRs in the UK is heavily dependent on taxpayer subsidies (as it would be in Australia) and it is far from certain to proceed to construction.[364]

11.7 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.[365] 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."[366]

Even the large-scale, standardised French nuclear power program has been subject to a negative learning curve.[367] The problem of escalating costs is worsening with the massive cost blowouts associated with the EPR projects in France and Finland.

[363] https://www.theaustralian.com.au/nation/politics/peter-dutton-vows-to-bring-small-nuclear-reactors-online-in-australia-by-mid2030-if-elected/news-story/eaf9eaf2084916fa118fbeebf2ed72c9
[364] https://www.crikey.com.au/2024/04/10/nuclear-power-peter-dutton-technology-dead-ends/
[365] 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/
[366] www.businessinsider.com.au/5-charts-that-show-nuclear-is-declining-2013-10
[367] 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

In 2009, an updated version of a 2003 MIT Interdisciplinary Study on the Future of Nuclear Power was published, stating:[368]
"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."[369]

Citigroup commented on three 'Corporate Killers' in a 2009 report:[370]
"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 project after the expenditure of at least US$9 billion (A$13.9 billion), as well as dramatic cost overruns with the Vogtle reactor project in the US state of Georgia.

11.8 False claims regarding renewable energy costs in Australia

In submissions to parliamentary inquiries, in the media and elsewhere, numerous nuclear advocates have made wildly inaccurate claims not only about nuclear costs but also about the cost of renewables. This problem was addressed by *RenewEconomy* editor Giles Parkinson in a 2019 article.[371] A brief excerpt from Parkinson's analysis is reproduced here:
"It is generally accepted in the energy industry that the cost of new nuclear is several times that of wind and solar, even when the latter are backed up by storage. The GenCost 2018

[368] http://web.mit.edu/nuclearpower/
[369] 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/
[370] Citigroup, 9 Nov 2009, 'New Nuclear - the Economics Say No: UK Green Lights New Nuclear – Or Does It?', http://nonuclear.se/files/SEU27102.pdf
[371] Giles Parkinson, RenewEconomy, 23 Oct 2019, 'Why the nuclear lobby makes stuff up about the cost of wind and solar, https://reneweconomy.com.au/why-the-nuclear-lobby-makes-stuff-up-about-cost-of-wind-and-solar-46538/
See also: Giles Parkinson, 28 Oct 2022, 'Dutton and Coalition still ignorant and deluded on battery storage and nuclear', https://reneweconomy.com.au/dutton-and-coalition-still-ignorant-and-deluded-on-battery-storage-and-nuclear/

report from the CSIRO and the Australian Energy Market Operator (AEMO) puts the cost of nuclear at two to three times the cost of "firmed renewables".
"The nuclear lobby, however, has been insisting to the parliamentary inquiry that wind and solar are four to seven times the cost of nuclear, and to try and prove the point the lobby has been making such extraordinary and outrageous claims that it makes you wonder if anything else they say about nuclear – its costs and safety – can be taken seriously.
"RenewEconomy has been going through the 290-something submissions and reading the public hearing transcripts, and has been struck by one consistent theme from the pro-nuclear organisations and ginger groups: When it comes to wind, solar and batteries, they just make stuff up.
"A typical example is the company SMR Nuclear Technology – backed by the coal baron Trevor St Baker – which borrows some highly questionable analysis to justify its claim that going 100 per cent renewables would cost "four times" that of replacing coal with nuclear.
"It bases this on modelling by a consultancy called EPC, based on the south coast of NSW, apparently a husband and wife team, Robert and Linda Barr, who are also co-authors of "The essential veterinarian's phone book", a guide to vets on how to set up telephone systems.
"The EPC report admits to deliberately ignoring the anticipated cost reductions of wind and solar from AEMO's 2018 integrated system plan. Even worse, the report dials in a completely absurd current cost of wind at A$157/MWh (before transmission costs), which is about three times the current cost in Australia, and A$117/MWh for solar, which is more than double.
"The costs of wind and solar are not hard to verify. They are included in the GenCost report, in numerous pieces of analysis, and even in public announcements from companies involved, both buyers and sellers."

11.9 Net Zero Australia report

Net Zero Australia – a partnership between the University of Melbourne, the University of Queensland, Princeton University and international management consultancy Nous Group – considered the potential role of nuclear power in Australia's future energy mix and concluded in its landmark 2023 report:[372]
"In the modelled sensitivity most favourable to nuclear deployment (constrained renewable build rate and low nuclear costs), nuclear produces a small proportion of energy.
• Nuclear energy is currently illegal in Australia. If it were legalised, and the renewable build constrained (E+RE-, Nuclear), it is modelled to produce 2 TWh or 0.1 per cent of domestic energy in 2050.
• If renewables are constrained, and the cost of nuclear is made 30 per cent lower than current international best practice (~A$5,200 / kW; E+RE-, CheapNuclear), it produces 78 TWh, or 4 per cent of domestic energy in 2050.
"To reduce renewable targets in the belief that nuclear will be deployed later at scale would create a material risk of not achieving net zero, or doing so at an excessive cost.

[372] https://www.netzeroaustralia.net.au/mobilisation-report/
https://www.netzeroaustralia.net.au/wp-content/uploads/2023/09/Net-Zero-Australia-Mobilisation-How-to-make-net-zero-happen-updated-19-Sep-23.pdf

"Australia has a large renewable energy base and general public acceptance of renewables. If nuclear is factored into the future energy mix, resulting in slower renewable deployment, the modelling suggests that would be a costly error, because it likely to be more expensive than renewables with firming.
"It is also likely to take much longer. Nuclear power stations take an average of 9.4 years to build, compared to 1-3 years for a major solar or wind project. Australia's lack of expertise and experience would likely make the lead time much longer.
"Nuclear should not be regarded as an alternative to renewables, but the option could be monitored as a hedge against the risks of the transition."

The Net Zero Australia Modelling Summary Report states:[373]
"Nuclear power was not permitted in any of the Core Scenarios, consistent with existing Commonwealth and State Laws. However, the use of nuclear is examined in one of the Sensitivity analyses. Our Sensitivities found that nuclear technology at a nominal cost of ~7,200 $/kW never plays a role. Nuclear capacity is installed only when: a) its capital cost is ~5,200 $/kW; and b) VRE deployment rates are constrained (the E+RE-CheapNuclear Sensitivity)."

Note that the assumed nuclear costs of A$5,200–7,200 / kW are far lower than real-world costs for nuclear construction projects in the USA (Vogtle: A$23,800 / kW) and the UK (Hinkley Point: A$27,900 / kW), and far lower than the latest NuScale SMR estimate (A$31,000 / kW).

At the launch of the Net Zero Australia report, Emeritus Professor Robin Batterham, Chair of the Net Zero Australia Steering Committee and former Australian Chief Scientist, said: "Nuclear power should not be in our plans, because it's too expensive and slow. Only a dramatic fall in costs and prolonged renewable constraints would prompt a rethink."[374]

There are important parallels between the Net Zero Australia analysis and CSIRO's GenCost analysis (see section 11.5 of this submission). Both make extremely generous assumptions about nuclear costs – indeed both assume costs several times lower than real-world experience in the UK and the US – yet nuclear power is still found to be uneconomic in Australia in both studies.

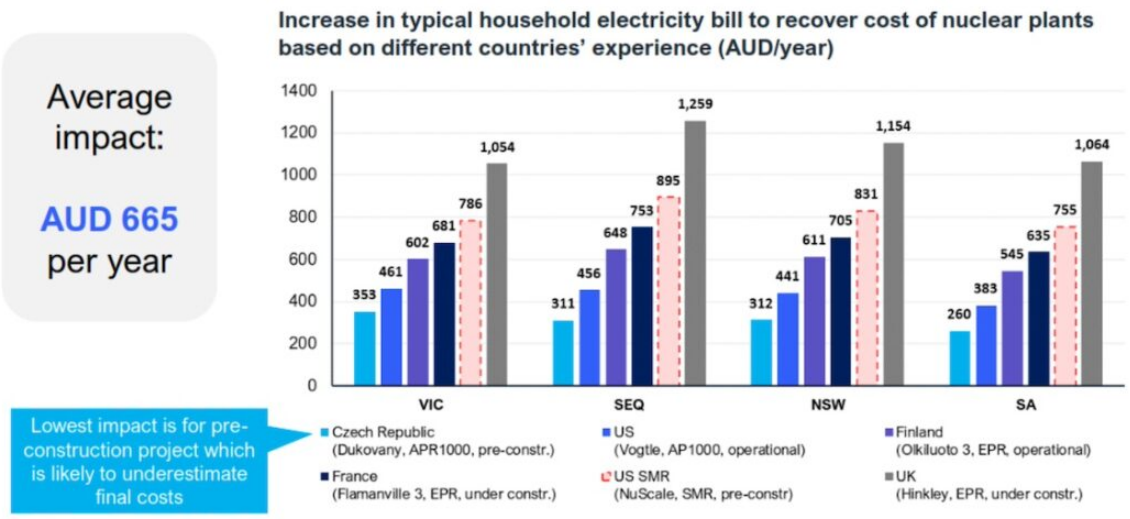
[373] https://www.netzeroaustralia.net.au/wp-content/uploads/2023/04/Net-Zero-Australia-Modelling-Summary-Report.pdf
[374] https://www.netzeroaustralia.net.au/news-mobilisation-report-launch/

12. THE IMPACT OF THE DEPLOYMENT, OPERATION AND MAINTENANCE OF NUCLEAR POWER STATIONS ON ELECTRICITY AFFORDABILITY

12.1 Nuclear power would increase power bills and taxes
12.2 Canada / Ontario as a model for Australia?

12.1 Nuclear power would increase power bills and taxes

A 2024 report by the Institute for Energy Economics and Financial Analysis presents the following 'key findings':[375]
* Typical Australian households could see electricity bills rise by A$665/year on average under the opposition Coalition's plans to introduce nuclear to the country's energy mix.
* IEEFA analysed six scenarios based on relevant international examples of nuclear power construction projects; in every scenario, bills increased by hundreds of dollars.
* For households that use more electricity, bills could rise more – for a four-person household, the bill rise was found to be A$972/year on average across nuclear scenarios and regions.
* The cost of electricity generated from nuclear plants would likely be 1.5 to 3.8 times the current cost of electricity generation in eastern Australia.



Source: Institute for Energy Economics and Financial Analysis

Of course, the impact on power bills could be reduced by shifting the additional costs onto taxpayers rather than ratepayers. Either way, Australians will pay more with the introduction of nuclear power; most likely, both power bills and taxes would increase.

[375] https://ieefa.org/sites/default/files/2024-09/Nuclear%20in%20Australia%20would%20increase%20household%20power%20bills_Sep24.pdf

Others have attempted to cost the Coalition's nuclear plans, a task made much more difficult by the lack of information provided by the Coalition. With that caveat, several assessments are summarised here.

A May 2024 report prepared for the Clean Energy Council by Egis, a leading global consulting, construction and engineering firm, presents these key findings:[376]
1. The research confirmed that nuclear energy is up to six times more expensive than renewable energy and even on the most favourable reading for nuclear, renewables remain the cheapest form of new-build electricity.
2. The safe operation of nuclear power requires strong nuclear safety regulations and enforcement agencies, none of which exist in Australia. Establishing these frameworks and new bodies would take a long time and require significant government funding which would ultimately be borne by taxpayers.
3. Nuclear may be even higher cost than currently forecast as waste management and decommissioning of nuclear plants have been omitted by cost calculations in the relevant research available.
4. The economic viability of nuclear energy will further diminish as more wind, solar and battery storage enters the grid, in line with legislated targets. Put simply, nuclear plants are too heavy and too slow to compete with renewables and can't survive on their own in Australian energy markets.

Apart from the practical constraints (not least the fact that they don't exist), the economics of SMRs would go from bad to worse if using them to complement renewables. According to the Institute for Energy Economics and Financial Analysis, power from an SMR with a utilisation factor of 25% would cost around A$600 per megawatt-hour (MWh).[377] Likewise, an article co-authored by Steven Hamilton – assistant professor of economics at George Washington University and visiting fellow at the Tax and Transfer Policy Institute at the ANU – states:[378]
"Opposition Leader Peter Dutton said: "Labor sees nuclear power as a competitor to renewables. The Coalition sees nuclear power as a companion to renewables".
"The trouble is that nuclear is a terrible companion to renewables. The defining characteristic of being "compatible" with renewables is the ability to scale up and down as needed to "firm" renewables.
"Even if we don't build a single new wind farm, in order to replace coal in firming renewables, nuclear would need to operate at around 60 per cent average utilisation (like coal today) to keep capacity in reserve for peak demand. This alone would push the cost of nuclear beyond $225/MWh. To replace gas as well, the cost skyrockets beyond $340/MWh."

[376] https://www.cleanenergycouncil.org.au/news/new-independent-research-nuclear-six-times-the-cost-of-renewables
[377] https://ieefa.org/resources/nuclear-options-new-research-smrs-raises-questions-over-australias-energy-debate
[378] https://www.brisbanetimes.com.au/politics/federal/nuclear-is-ok-if-it-makes-economic-sense-but-mr-dutton-in-australia-it-doesn-t-20240317-p5fd1s.html

A June 23, 2024 article in the Australian Financial Review by Steven Hamilton and Luke Heeney, titled 'Nuclear is unviable because of economics, not engineering', states:[379]

Even if all that mattered was the cheapest possible energy that meets minimum levels of reliability and emissions, the Coalition's plan fails. …

The numbers don't stack up for nuclear

The CSIRO estimates the cost of 90 per cent renewables, with firming, transmission, and integration costs included, at $109 per megawatt hour. Based on South Korean costs (roughly one-third of the US and Europe), a 60-year lifespan, a 60 per cent economic utilisation rate (as per coal today), and an eight-year build time (as per the global average), nuclear would cost $200 per megawatt hour – nearly double.

The same electrons delivered with the same reliability, just twice as expensive under what is a fairly optimistic scenario.

Opposition climate and energy spokesman Ted O'Brien has raised two issues with the CSIRO's assumptions for nuclear: first, lifespan (Ted says it should be 80 years); second, utilisation (Ted says it should be close to 100 per cent).

His first concern makes little difference. Thanks to the time value of money, extending the lifespan from 60 to 80 years reduces the cost above by just $4 per megawatt hour – or 2 per cent. His second concern misunderstands the Australian energy market.

Because the vast majority of nuclear costs are up-front capital, utilisation has a dramatic effect on economic viability. Even if nuclear were to supply 100 per cent of electricity, utilisation would not be 100 per cent because demand varies dramatically.

In France, where nuclear accounts for most of the supply, utilisation is just 70 per cent —and that's with a big boost to utilisation as energy can be exported to countries to its east and west, which plainly Australia could not do.

Underutilisation then gets even worse as the supply of renewables increases. When competing with zero-marginal-cost renewables, nuclear must either decrease output (thus utilisation) or supply at negative prices (reducing economic viability, as with coal today). Renewables already routinely produce more than half our electricity during the day and AEMO expects average renewables output to exceed 95 per cent (and up to 100 per cent at times) by 2035, when the Opposition plans the first nuclear plant to come online. In that environment, even the 70 per cent achieved in France would be wildly optimistic.

The same electrons delivered with the same reliability, just twice as expensive under what is a fairly optimistic scenario.

It's worth noting that, even at 93 per cent utilisation (the highest ever achieved in the US where nuclear is a small share of supply), nuclear is still 25 per cent more expensive than renewables.

This is also where the opposition's claim that nuclear will ensure system reliability falls apart. For nuclear, the goals of reliability and viability are fundamentally opposed. To bring nuclear closer to economic viability, it must play a minor role in the system to consistently run at full capacity, with nothing more to give when called upon.

A genuine reliability solution should be available when needed at minimum cost. Today, that means gas, batteries and pumped hydro. In 2050, it could also mean small modular nuclear reactors. But we have a quarter-century to wait and see if they become economically viable.

[379] https://www.afr.com/policy/energy-and-climate/nuclear-is-unviable-because-of-economics-not-engineering-20240623-p5jny1

Are there uncertainties around the cost of firmed renewables? Independent analysis by Lazard and peer-reviewed academic research produce similar estimates to the CSIRO. We must make decisions today based on our best guess of the costs. But any concerns about delays, social license and cost blowouts are surely even greater under nuclear, and it starts at a 100% cost disadvantage before these even enter the picture.
If you need external validation of these basic economics, look no further than the opposition's own announcement. Rather than lift the moratorium and allow private firms to supply nuclear energy if it's commercially viable, the opposition has opted for government to be the owner and operator. A smoking gun of economic unviability if ever there were one.
In the face of an intractable productivity crisis, in which we must take every 10th of a percentage point of GDP we can get, choosing to pay more for electricity for no benefit whatsoever is unacceptable self-harm.
In these circumstances, the pragmatist should view the opposition's plan as nothing more than a vanity project our economy cannot afford.

A 21 June 2024 article in *The Guardian* provides these expert opinions:[380]
Australians' annual household power bills could increase by hundreds of dollars, and up to $1,000, under a Coalition plan to slow the rollout of large-scale renewable energy and use more gas-fired electricity before nuclear plants are ready, analysts say. …
Analysts said gas was a far more expensive power source in the national grid than renewable energy or coal, and opening new gas basins was unlikely to change this as the country's cheap gas had already been extracted. They said adding more gas power could also increase greenhouse gas emissions, accelerating the climate crisis.
Tristan Edis, a director with the firm Green Energy Markets, said the wholesale electricity price was set by the most expensive fuel being used at any given time. Those prices were "very high" – between $250 and $300 per megawatt hour of electricity, about three times the average price – whenever fast-start gas plants were used to complement cheaper coal, solar, wind and hydro energy.
Gas now provides less than 5% of electricity in the national electricity market, and is only called on when needed to meet demand.
Edis said if a Coalition government put a hold on investment in solar and windfarms and boosted gas power so that it was replacing coal and always setting the price, "you're talking about an increase of $500 to potentially even $1,000 per annum for a household power bill".
Dr Roger Dargaville, an associate professor and the interim director of the Monash Energy Institute, said it was difficult to predict what the Coalition's announcement would mean for bills due to a lack of detail, but agreed the increase in an annual bill could be $1,000.
"It seems the options being presented will either lead to extraordinary maintenance bills to keep old coal plants going or using a lot more gas," he said. "Coal is a very cheap fuel, so if you're going from a coal-dominated system to a gas-dominated system, you are going to see very steep energy prices."
Dargaville said more renewable energy backed by "firming" support – including energy storage, new transmission lines and gas power only when required – was "the only sensible option and almost certainly the least cost option". …

[380] https://www.theguardian.com/australia-news/article/2024/jun/21/power-bills-could-rise-by-1000-a-year-under-coalition-plan-to-boost-gas-until-nuclear-is-ready-analysts-say

12.2 Canada / Ontario as a model for Australia?

A recent report by the Institute of Energy Economics and Financial Analysis (IEEFA) states:[381]
"[I]n almost all cases around the world, the cost of nuclear power plant construction and financing is not fully reflected in market prices for power. This is because either nuclear power plants are very old and their costs are largely depreciated, or governments have acted to recover the costs either through taxpayers, or via levies which are independent of electricity markets – for example in France, the UK and Ontario, Canada. In other jurisdictions, such as a number of US states including Georgia where the Vogtle power plant is located, there isn't actually an electricity market in operation, with consumers instead served by a regulated monopoly without any competitive choice." (pp.8-9)
"The Coalition has cited Ontario, Canada, as a state with lower power prices in a high nuclear grid (59% nuclear). However, Ontario's lower retail electricity bill costs are largely a function of low network costs and government power price subsidies. Ontario consumers pay for network costs via a charge which is separate to their kWh price charges and is denoted on the bill as "delivery", whereas in Australia network fees make up a large proportion of kWh price charges.
"More importantly, disastrous blow-outs in the cost of Ontario's nuclear build program aren't fully reflected in current power prices. In fact, Ontario was forced to undertake a major restructure of its electricity sector in the 1990's due to the fact that the state-owned utility had accumulated unsustainable debts of CAD38.1 billion (as at 1999) due to large cost blow-outs in its nuclear build program and poor utilisation of these assets. Under this restructure, CAD20.9 billion (1999 Canadian dollars) of Ontario Hydro's debt was declared by the Ontario Electricity Financial Corporation as stranded debt which 'cannot reasonably be serviced and retired in a competitive electricity market.'" (p.28)

Adam Morton noted in *The Guardian*:[382]
"[T]the Coalition argues the nuclear experience in Ontario, Canada, demonstrates that nuclear energy is cheaper than Australian renewable energy. This is not a relevant comparison. Like France, Ontario runs on nuclear plants built decades ago. Construction costs in the 1980s tell us nothing about the costs in the 2030s and 2040s.
"Even then, the claim electricity is cheaper in Ontario is misleading. Wholesale electricity prices – the only part of the bill that is affected by the cost of generation – in Ontario are actually higher than the cost of new firmed renewable energy in Victoria and Queensland.
"A more relevant comparison may be the ongoing construction of the large Hinkley C generator in the UK. It was initially expected to open in 2017 and cost about A$34bn. That has now been pushed out to 2031, and up to A$89bn."

In a detailed critique, energy market analyst Tristan Edis states:[383]

[381] Johanna Bowyer and Tristan Edis, 'Nuclear in Australia would increase household power bills', Institute of Energy Economics and Financial Analysis, September 2024
https://ieefa.org/resources/nuclear-australia-would-increase-household-power-bills
[382] https://www.theguardian.com/australia-news/article/2024/jun/20/does-the-coalitions-case-for-nuclear-power-stack-up-we-factcheck-seven-key-claims
[383] https://reneweconomy.com.au/ontarios-huge-nuclear-debt-and-other-things-dutton-doesnt-understand-about-cost-of-electricity/

Once you actually delve into these numbers it becomes apparent that O'Brien and Dutton don't seem know much about electricity costs and pricing.
But even worse, they don't know how badly Ontario's taxpayers and electricity consumers were burnt by their utility racking up huge debt building nuclear power plants equal to $70 billion in current day Australian dollars. …
So, rather than paying four times more than the 14.3 cents Ontario households pay for electricity, we actually pay anywhere between 1% to 19% less. …
Yet this comparison between Ontario and Australia misses a far more important part of the story that O'Brien and Dutton seem to be blissfully ignorant of.
That is the history of the Ontario's state owned utility – Ontario Hydro – and the unsustainable level of debt that it racked up over the 1980's and 1990's as a result of an ambitious nuclear plant construction program that went wrong. …
By 1998 the Ontario government came to the uncomfortable conclusion that its monopoly utility had monumentally screwed-up and it was time to break the thing up and rely on competition to ensure better outcomes for Ontario residents.
The problem was that the level of debt the utility had racked up was of a level that, if this was transferred to the new broken-up offshoots, it would leave them saddled with such high debts that they were financially unstable and prone to collapse. …
So the CAD$38.1 billion in debt was transferred out of the electricity companies and into a special purpose government entity called the Ontario Electricity Financial Corporation (OEFC). This debt management corporation was given the following revenues to service the debt:
– Both residential and business consumers were required to pay a special "Debt Retirement Charge". This charge was introduced in 2002 and lasted until 2016 for residential consumers and 2018 for business customers.
– The Ontario government would forgo any corporate income and other taxes owed by the offshoot electricity companies from Ontario Hydro so they could be diverted to the OEFC to pay down debt.
– If the cumulative profits of two of the new state power companies exceeded the $520m annual interest cost on their debts, then this would go towards paying stranded debt rather than dividends to the Ontario government.
None of this is apparent on current bills, but the burden of repaying the nuclear debt left the Ontario government and its taxpayers far poorer than Dutton and O'Brien seem to appreciate. …
Ontario taxpayers on the other hand realised far too late that their public utility, in cahoots with their politicians, were pursuing a nuclear vanity project built upon a poor understanding of the future, and without any competitor to discipline their ego. …
Unfortunately for us, Dutton and O'Brien are also in a hurry. They think they can deliver nuclear power plants far faster than what many experts believe is sensible and what many countries with far more nuclear experience than ourselves have been able to achieve. Dutton and O'Brien also want to do this via a government-owned utility, instead of via a competitive market.

Mark Winfield, a professor at the faculty of environmental and urban change at York University, writes:[384]

The Australian opposition leader seems to be operating on a very limited understanding of the history and current state of electricity, energy, and climate policy in Ontario. A good starting point would be the delays and cost overruns flowing from the province's initial 20-reactor nuclear construction program. Running from the 1960s through the early 1990s, they effectively bankrupted the provincially-owned utility Ontario Hydro. Its successor, Ontario Power Generation (OPG), could only be made economically viable by offloading nearly C$21 billion in mostly nuclear-related debt onto electricity ratepayers.

Poor maintenance and operating practices led to the near-overnight shutdown of the province's seven oldest reactors in 1997, leading to a dramatic rise in the role of coal-fired generation and its associated emissions of greenhouse gases (GHGs) and smog precursors. The refurbishment of the "laid-up" reactors themselves went badly. Two ended in write-offs, and the others ran billions over budget and years behind schedule, accounting for a large portion of the near doubling of electricity rates in the province between the mid-2000s and 2020. …

There is a second dimension to Ontario's electricity plans that should not be overlooked. Upon arriving in office, the Ford government promptly terminated all efforts at renewable energy development, including having completed wind turbine projects quite literally ripped out of the ground at a cost of hundreds of millions of dollars. It then scrapped the province's energy efficiency strategy for being too effective at reducing demand. Repeated offers of low-cost electricity from the hydropower-rich neighbouring province of Quebec were ignored. The results of studies by the province's own electricity system operator on energy efficiency potential and the possible contributions of distributed generation, like building- and facility-level solar photovoltaics (PV) and storage, have been largely disregarded.

These choices have left the province with no apparent option but to rely on natural gas-fired generation to replace nuclear facilities that are being refurbished or retired. …

Given all of this, it would be difficult to see Ontario as a model for Australia or any other jurisdiction to follow in designing its energy and climate strategy. The province has no meaningful energy planning and review process. Its current nuclear- and gas-focused pathway seems destined to embed high energy costs and high emissions for decades to come. And it will leave a growing legacy of radioactive wastes that will require management on time scales hundreds of millennia.

A rational and transparent process would prioritize the options with the lowest economic, environmental, technological, and safety risks. Higher-risk options, like new nuclear, should only be considered where it can be demonstrated that the lower-risk options have been fully optimized and developed in the planning process. Ontario's current path goes in the opposite direction. To follow its example would be a serious mistake.

Graham Readfern writes in The Guardian:[385]

So does nuclear mean cheap power for Ontario?

First, let's start with Ontario's electricity mix. The province has 20 of Canada's 22 nuclear reactors, providing about 59% of Ontario's electricity.

[384] https://www.theenergymix.com/you-couldnt-make-this-up-ontario-is-no-model-for-climate-and-energy-winfield-warns-australia/

[385] https://www.theguardian.com/environment/article/2024/aug/01/peter-dutton-nuclear-power-plan-cost-price-canada-ontario

But comparisons of electricity prices across Canada and North America don't show that Ontario's nuclear-heavy generation delivers particularly cheap power.
According to two analyses (here and here), Quebec, the province next door where almost all electricity comes from hydropower, gives the cheapest rates. British Columbia and Manitoba are also cheaper, and they're also dominated by hydro.
Dutton has said Ontarians "pay around about 14 cents kWh. There are parts in Australia that will be paying up to 56 cents a kilowatt hour from July 1 this year."
But making a fair comparison between Australian electricity prices and Ontario is almost impossible because – before we've even got to the subsidy – the structures and governance systems around electricity are very different.
Almost half of Ontario's power generation is publicly owned and the prices people pay are set by a government board.
Ontarians pay for their electricity in a more sophisticated way than Australians – people can choose one of three price plans, and the price people pay for each kWh can depend, for example, on how much power they have used that month or what time of day they are using it. The cost to the customer per kWh can be as low as 3c/kWh and as high as 32c/kWh.
But Winfield says the $8bn annual subsidy that helps keep those costs down is also masking the cost of refurbishing Ontario's existing fleet of reactors that were built between the 1970s and 1990s.
"Those projects have consistently run billions over budget and years behind schedule, and in some cases ended in write-offs," Winfield says.
The provincial government wants to refurbish 10 of its reactors. Winfield says the cost of those refurbs isn't known, but his own estimates stand at about $44bn.
Ontario's government has a chequered recent history when it comes to energy policy.
Critics have pointed to the province's "horrifically expensive" nuclear reactors that helped the collapse of the publicly owned generator in the 1990s with $42bn of debt, and ratepayers were asked to repay some of that with a charge they continued to pay until 2018.
In 2018, the provincial government cancelled 758 renewable projects, reportedly costing Ontarians about $250m.
Winfield says Ontario's decision to sideline renewables and back nuclear will see the province relying more on gas, which he says will push up greenhouse gas emissions.
"The fundamental underlying problem, along with all of the other downsides with nuclear – waste management, major upstream impacts in terms of uranium mining and milling, security, catastrophic accident and weapons proliferation risks that just don't exist in relation to other energy technologies – is that it hasn't benefited from the kinds of learning curves you have seen with renewables and storage, where costs have fallen and performance improved," he says.
"Rather, nuclear costs just keep rising."

Tim Buckley and Annemarie Jonson wrote in the Australian Financial Review:[386]
In Canada, which opposition energy spokesman Ted O'Brien admiringly cites, the last nuclear plant was approved in 1977 and commissioned 15 years later in 1993, five years late. The original capital cost of $C3.9 billion blew out 400 per cent to $C14.4 billion, including a $C600 million refurbishment immediately on commissioning, and it now needs another $C12

[386] https://www.afr.com/policy/energy-and-climate/coalition-s-taxpayer-funded-nuclear-con-a-road-to-ruin-20240624-p5jo3j

billion ($13.2 billion) refurbishment.
The Coalition's government-owned nuclear scheme emulates its great public infrastructure debacles – Snowy 2.0 and the NBN. Snowy 2.0 was due in 2021 at a cost of $2 billion. After a rolling series of crises, it's now expected to come online after 2028 and cost $15 billion. …
In short, while nuclear may be part of the energy mix in some countries with a long-established history of deploying the technology – in Canada, for example, it was 14 per cent of total generation in 2023 (down from 16 per cent a decade ago), while renewables are 65 per cent and increasing – it is simply not viable here.

Simon Holmes à Court states that the electricity dispatch rules were changed in Ontario to give nuclear priority over renewables, to account for their nuclear fleet's inability to quickly ramp up after being turned down.[387]

13. SOCIAL LICENSE

13.1 The Coalition's intention to override public opposition
13.2 Public opinion
13.3 Nuclear waste management and the rights of Australia's First Nations
13.4 Other sectors: trade unions and scientists

13.1 The Coalition's intention to override public opposition

Evidently the Coalition will override public opposition in communities targeted for nuclear reactors. Nationals' deputy leader Perin Davey said that the Coalition would not impose nuclear power plants on communities that were adamantly opposed.[388] Davey was corrected by Nationals leader David Littleproud, who said: "She is not correct and we made this very clear. Peter Dutton and David Littleproud as part of a Coalition government are prepared to make the tough decisions in the national interest."[389] Likewise, opposition leader Peter Dutton said: "Perin I think made a mistake yesterday as everybody does from time to time…. We've identified the seven locations and we believe it's in the community's interests and the national interest to proceed."[390]

Current attitudes stand in stark contrast to a 2019 parliamentary inquiry led by current shadow energy minister Ted O'Brien. The Committee's report was titled 'Not without your approval: a way forward for nuclear technology in Australia'.[391] Announcing the release of the parliamentary report, Mr. O'Brien said that a future government should only proceed with nuclear power on the condition that it make "a commitment to community consent as

[387] https://x.com/simonahac/status/1815281231187337700
[388] https://www.abc.net.au/news/2024-06-20/coalition-backs-away-from-nuclear-consent-community-call/103998784
[389] https://www.abc.net.au/news/2024-06-20/coalition-backs-away-from-nuclear-consent-community-call/103998784
[390] https://www.abc.net.au/news/2024-06-20/coalition-backs-away-from-nuclear-consent-community-call/103998784
[391] https://www.aph.gov.au/Parliamentary_Business/Committees/House/Former_Committees/Environment_and_Energy/Nuclearenergy/Report

a condition of approval for any nuclear power or nuclear waste disposal facility" and he talked about "maintaining a social license based on trust and transparency" and putting the Australian people "at the centre of any approval process".[392]

13.2 Public opinion

A Newspoll survey led to a February 26, 2024 page-one article in the *Australian* under the headline 'Powerful majority supports nuclear option for energy security'.[393] But the Newspoll survey was just another example of push-polling and was criticised by polling experts Kevin Bonham[394] and Murray Goot[395] and by economist Prof. John Quiggin.[396]

In unbiased polls over the past five years, support for nuclear power in Australia exceeds opposition in most of polls, but support rarely reaches a majority.[397]

Dr. Rebecca Huntley, director of research at 89 Degrees East, told the *Nine* newspapers that participants in focus groups were bringing up nuclear power more often than before the last federal election, but support usually dissolved once the discussion turned to timelines, logistics and the issue of how to store nuclear waste.[398]

Kos Samaras, founder of research consultancy RedBridge, told the *Nine* newspapers that the question of social licence would be impossible to overcome because soft support for nuclear power would evaporate and bump up against hard opposition which he puts as high as 32%.[399]

In the February 2024 Newspoll survey, support for building SMRs on the sites of retired coal plants received strong support from younger poll respondents (65% support, 32% opposition). However the poll was biased and as Murray Goot notes, other polls reach different conclusions: "But eighteen- to thirty-four-year-olds as the age group most

[392] https://www.aph.gov.au/About_Parliament/House_of_Representatives/About_the_House_News/Media_Releases/Nuclear_Energy_-_Not_without_your_approval

[393] https://edition.pagesuite.com/popovers/dynamic_article_popover.aspx?artguid=5748b571-79fe-454a-9b7e-b6f542487715

[394] https://www.theguardian.com/environment/2024/feb/29/the-australian-newspoll-survey-small-modular-nuclear-reactors-smr-energy-grid-plan

[395] https://insidestory.org.au/nuclear-power-newspoll-and-the-nuances-of-polled-opinion/

[396] https://theconversation.com/dutton-wants-a-mature-debate-about-nuclear-power-by-the-time-weve-had-one-new-plants-will-be-too-late-to-replace-coal-224513

[397] https://reneweconomy.com.au/peter-duttons-nuclear-push-is-a-suicide-note-playing-mostly-to-right-wing-echo-chambers/

[398] https://www.theage.com.au/environment/climate-change/a-new-generation-is-talking-nuclear-power-it-s-unlikely-to-happen-20240313-p5fc3b.html

[399] https://www.theage.com.au/environment/climate-change/a-new-generation-is-talking-nuclear-power-it-s-unlikely-to-happen-20240313-p5fc3b.html

favourably disposed to nuclear power is not what Essential[400] shows, not what Savanta[401] shows, and not what RedBridge[402] shows."[403]

Tony Barry, a former deputy state director and strategist for the Victorian Liberal Party, is now a director at the research consultancy RedBridge. On the strength of a detailed RedBridge analysis of Australians' attitudes to nuclear power, he states that just 35% of Australians support nuclear power (only coal is less popular) and that support is skewed towards those who already vote for the Coalition and those who are over 65.[404]

Since then, nuclear power has regained its status as Australian's least popular energy source. The *Australian Financial Review* reported:[405]
As the election draws closer, the latest The Australian Financial Review/Freshwater Strategy poll shows nuclear energy is failing to gain traction with voters.
After seven months, it has fallen behind coal to seize back the mantle as the nation's least favoured method of generating electricity.
While 34 per cent support nuclear power, 36 per cent oppose it, giving it a net approval rating of minus 2, putting it in last place behind coal which has a net approval of plus 5.
The most popular power source is rooftop solar (plus 80), followed by solar farms (plus 60), natural gas (plus 46), offshore wind and onshore wind (both plus 37) and hydrogen (plus 32).
In March, when Opposition Leader Peter Dutton announced a Coalition government would build, own and operate seven nuclear power plants, nuclear energy moved just ahead of coal and stayed there until the most recent poll, which sampled 1034 voters from last Friday to Sunday,
While the latest fall in support for nuclear is within the poll's 3.1 per cent margin of error, Freshwater Strategy director Michael Turner said, "one thing you can definitely say is that it has not made ground" over the past six months.

In June 2024, the Australia Institute released the results of a survey of 1,005 Australians that it commissioned from the firm Dynata in May. It found nearly two-thirds (65%) of respondents said they were not prepared to pay extra to have nuclear power in the mix.[406]

Unbiased polls find that Australians support renewables to a far greater extent than nuclear power; that a majority do not want nuclear reactors built near where they live; and that most Australians are concerned about nuclear accidents and nuclear waste.

[400] https://essentialreport.com.au/questions/support-for-nuclear-energy
[401] https://www.radiantenergygroup.com/reports/public-attitudes-toward-clean-energy-nuclear
[402] https://www.thesaturdaypaper.com.au/news/politics/2024/03/09/can-peter-dutton-actually-win-enough-seats-form-government
[403] https://insidestory.org.au/nuclear-power-newspoll-and-the-nuances-of-polled-opinion/
[404] https://www.thesaturdaypaper.com.au/news/politics/2024/03/09/can-peter-dutton-actually-win-enough-seats-form-governmenthttps:/www.thesaturdaypaper.com.au/news/politics/2024/03/09/can-peter-dutton-actually-win-enough-seats-form-government
[405] https://www.afr.com/politics/federal/csiro-might-revise-nuclear-power-cost-claims-20241023-p5kkig
[406] https://www.theguardian.com/australia-news/article/2024/jun/21/power-bills-could-rise-by-1000-a-year-under-coalition-plan-to-boost-gas-until-nuclear-is-ready-analysts-say

Opposition to locally-built nuclear power reactors has been clear and consistent for 20 years or more.[407] For example, a 2023 *AFR* / Freshwater Strategy Poll found that around one-quarter of voters would tolerate a nuclear plant being built within 50 km of their home, while a majority (53%) would oppose it.[408] *News Corp.* reported on April 7, 2024 that focus group research carried out in the Hunter Valley in NSW and the Latrobe Valley in Victoria found that voters are “hostile” to plans for reactors in their own areas.[409] Likewise, polling in Gippsland by Redbridge Group found that participants are overwhelmingly against the idea of having a nuclear power plant constructed in their region.[410]

In February 2024 a national poll of 1,012 Australian by Glow Market Research found:[411]
* 72% of Australians believe we should continue the shift to renewable energy rather than build nuclear energy (17%) or new coal (11%).
* 76% of Australians would prefer to live near renewable energy projects, like wind and solar farms, than near nuclear (12%) or coal (11%).
* 75% of Australians think the number one way to bring down power bills quickly is to build more renewable energy and batteries or subsidise rooftop solar.

Polling consistently shows that Australians are concerned about nuclear accidents and the nuclear waste legacy.[412] Proponents would need to convince residents living in the vicinity of proposed nuclear reactors to accept the "non-negligible" risk of a “catastrophic failing within a nuclear system”, to use the words of Dr. Ziggy Switkowski.[413] The difficulty or impossibility of insuring against losses from a nuclear accident would concern local residents, just as it did when a previous government was progressing plans for a new nuclear research reactor at Lucas Heights, south of Sydney.[414]

[407] https://reneweconomy.com.au/peter-duttons-nuclear-push-is-a-suicide-note-playing-mostly-to-right-wing-echo-chambers/

[408] https://freshwaterstrategy.com/2023/09/26/afr-freshwater-strategy-poll-insights-on-nuclear-energy-and-other-sources/

[409] https://www.adelaidenow.com.au/news/nsw/peter-dutton-to-press-ahead-with-nuclear-despite-opposition-in-regional-australia/news-story/53a7108e83484542ee99870d5002fba9

[410] https://www.skynews.com.au/australia-news/politics/australians-completely-against-nuclear-construction-in-their-neighbourhood/video/37941c3d2df53503e20036d202a81784

[411] https://www.acf.org.au/majority-of-australians-would-rather-live-near-wind-and-solar-than-nuclear-and-coal

[412] https://reneweconomy.com.au/peter-duttons-nuclear-push-is-a-suicide-note-playing-mostly-to-right-wing-echo-chambers/

[413] https://parlinfo.aph.gov.au/parlInfo/search/display/display.w3p;db=COMMITTEES;id=committees%2Fcommrep%2F3abfb90c-9215-4b65-a5d2-32d112e8cd46%2F0001;query=Id%3A%22committees%2Fcommrep%2F3abfb90c-9215-4b65-a5d2-32d112e8cd46%2F0000%22

[414] https://webarchive.nla.gov.au/awa/20090226033425/http:/pandora.nla.gov.au/pan/30410/20090218-0153/www.geocities.com/jimgreen3/insurance.html

13.3 Nuclear waste management and the rights of Australia's First Nations

A nuclear power program would of course generate streams of low-, intermediate- and high-level nuclear waste (see section 4.2).

In Australia, successive governments have for more than 25 years been trying to establish a national radioactive waste 'facility' comprising a repository for low-level waste and a store for long-lived intermediate-level waste. All four efforts have failed: the Woomera, SA proposal (initiated in 2006, abandoned in 2014); Muckaty, NT (2005–2014); Flinders Ranges, SA (2016–2019); and Kimba, SA (2017–2023).[415]

Aboriginal people led all four of those successful struggles. The opposition of Aboriginal people to a proposal to establish a large nuclear waste import and storage/disposal business in South Australia was a significant factor leading to the abandonment of the proposal in 2017.[416]

The National Radioactive Waste Management Act (NRWMA), federal legislation guiding recent attempts to establish a national waste facility, goes to great lengths to disempower and dispossess First Nations peoples.[417] The legislation permits the imposition of radioactive waste facilities even if affected First Nations people were not consulted and did not provide informed consent (to be precise, the nomination of a site is not invalidated by a failure to consult or secure consent). The NRWMA includes clauses which nullify state/territory laws that protect the archaeological or heritage values of land or objects, 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. The Native Title Act 1993 is expressly overridden in relation to land acquisition for a radioactive waste facility.

It is difficult to see how consultation could be respectful, and any agreement freely entered into, when the government enters negotiations with the NRWMA legislation allowing First Nations people to be ignored and to be stripped of existing rights and protections at federal and state/territory levels. The attitude of successive governments has been the antithesis of the United Nations Declaration on the Rights of Indigenous Peoples, which states that ''no storage or disposal of hazardous materials shall take place in the lands or territories of indigenous peoples without their free, prior and informed consent''.[418]

In October 2023 Dr. Marcos Orellana, UN Special Rapporteur on Toxics and Human Rights visited Australia, hearing from a diverse range of experts on the implications for human rights of the management of hazardous substances and wastes. His initial report noted:[419]

[415] https://www.apln.network/projects/voices-from-pacific-island-countries/the-politics-of-nuclear-waste-disposal-lessons-from-australia
[416] https://nuclear.foe.org.au/waste-import/
[417] https://www.apln.network/projects/voices-from-pacific-island-countries/the-politics-of-nuclear-waste-disposal-lessons-from-australia
[418] http://www.un.org/esa/socdev/unpfii/documents/DRIPS_en.pdf
[419] https://www.un.org/sites/un2.un.org/files/eom_-_08_sep_2023_-_final_.pdf

"It is instructive that all siting initiatives by the Government for a radioactive waste repository have failed, leaving a legacy of division and acrimony in the communities. … Alignment of regulations with the UN Declaration on the Rights of Indigenous Peoples is a critical step in the path towards healing open wounds of past environmental injustices."

Federal Parliament's Joint Standing Committee on Aboriginal and Torres Strait Islander Affairs, in its November 2023 report on the Inquiry into the application of the United Nations Declaration on the Rights of Indigenous Peoples in Australia, recommended that the Commonwealth Government ensure its approach to developing legislation and policy should be consistent with the Articles outlined in the United Nations Declaration on the Rights of Indigenous Peoples, and that a National Action Plan should be developed to implement, and assess compliance with, the Declaration.[420]

13.4 Other sectors: trade unions and scientists

Energy industry opposition to the Coalition's nuclear power plans was discussed in section 10 of this submission. Public opposition is discussed above in section 13.2. The Coalition's nuclear plan also lacks support from scientists, trade unions and other sectors.

Trade unions

The Australian newspaper noted the Australian Workers Union's (AWU) support for nuclear power earlier this year.[421] However, the newspaper failed to mention the opposition of the Australian Council of Trade Unions, Australian Education Union, Australian Manufacturing Workers Union, Australian Nursing and Midwifery Federation, Australian Services Union, Communication Workers Union, Electrical Trades Union, Independent Education Union (Vic - Tas), Maritime Union of Australia, National Union of Workers, Tasmanian Unions, Unions ACT, Unions WA, Unions SA, Unions NT, United Voice, United Firefighters Union, and the Victorian Trades Hall Council.[422]

Moreover, while the AWU has supported nuclear power previously, it is highly critical of the Coalition's nuclear plan. AWU national secretary Paul Farrow describes the Coalition's policy as a "half-baked fantasy" that will "slam the brakes on our energy transition and put our industries in peril", and urged the Coalition to "give up its nuclear dreaming".[423]

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420 https://www.aph.gov.au/Parliamentary_Business/Committees/Joint/Aboriginal_and_Torres_Strait_Islander_Affairs/UNDRIP/Report

421 https://www.theaustralian.com.au/inquirer/highstakes-power-play-will-shape-the-future-of-our-energy-security/news-story/dd29c56ca8f22e79a454b3cf740f608e

422 https://nuclear.foe.org.au/civil-society-statement-opposing-nuclear-power-in-australia/

423 https://www.skynews.com.au/australia-news/politics/two-laboraligned-unions-accused-of-backflipping-on-their-long-held-support-for-nuclear-energy-after-coalition-policy-announcement/news-story/4ea2de9a4d36cfdb958e4ed69a03f1e6

Likewise, the Mining and Energy Union (formerly the CFMEU's mining and energy division) has previously expressed general support for nuclear power but its response to the Coalition's nuclear power plan has been highly critical:[424]

Nuclear power stations will not provide a pathway into new employment for workers in the coal-fired power industry and the current debate is a distraction from securing new jobs in regions affected by energy transition, the Mining and Energy Union said today.

With Peter Dutton's Coalition announcing seven coal power stations as sites for nuclear power stations, the MEU said workers and communities needed viable new industries sooner than could be provided by nuclear.

"We are at a critical moment where workers are facing closures in the next few years," said the MEU General Secretary, Grahame Kelly.

"Even if nuclear energy was a popular option, according to the CSIRO, the earliest a large-scale nuclear plant could commence operations is no sooner than 2040.

"The clock is ticking; we need to be focusing our efforts on delivering an orderly transition for the thousands of workers and their communities who are staring down the barrel of the energy transition now." …

"Power stations in the proposed sites for nuclear would be long closed before the plants would become operational, and if no support is provided, those workers and communities will have already packed up their lives and moved on.

"Now is not the time for distractions. We need to be acting to deliver an orderly transition that focuses on jobs, economic activity in affected regions and positive social outcomes for affected workers while we still have the chance.

"We are also disappointed the Coalition has announced this policy with no consultation with these coal power regions about whether they want a nuclear future."

The ACTU responded to the Coalition's June 19, 2024 announcement as follows:[425]

The ACTU condemns Peter Dutton's election promise of building nuclear power plants as 'dangerous' and 'costly' for Australian workers. …

Dutton's proposal lacks key details of serious concern to workers, such as the handling and disposal of nuclear waste and the transportation of radioactive materials through Australian communities. Nuclear waste lasts thousands of years and requires burial hundreds of metres below ground in concrete bunkers.

Australia has the most sun and wind per capita of any developed country and evidence shows renewables continue to be the single cheapest source of new power on the grid.

The ACTU warns that Dutton's proposal would derail Australia's path to cheaper and cleaner energy, including the hundreds of thousands of good new jobs to be created as part of the federal government's plan to transform Australia into a renewable energy superpower with the Future Made in Australia policy.

ACTU President Michele O'Neil said:[426]

"Peter Dutton's nuclear fantasy is costly for workers, expensive for families and dangerous for local communities.

"Working people in these communities need good, secure, safe jobs now – not in 20 years time with no plan or detail.

[424] https://meu.org.au/nuclear-plans-no-help-for-coal-power-workers-meu/
[425] https://www.actu.org.au/media-release/duttons-dangerous-nuclear-fantasy-will-cost-workers-says-actu/
[426] https://www.actu.org.au/media-release/duttons-dangerous-nuclear-fantasy-will-cost-workers-says-actu/

"All the experts agree that nuclear power is slow, expensive, and dangerous. This will mean higher power prices, fewer clean energy jobs, and greater risks for workers' health and safety.
"Dutton wants to put workers' safety and livelihoods at risk, all so he can appease climate change deniers in the Coalition who oppose clean energy.
"From opposing workers' rights to promoting his nuclear fantasy, Peter Dutton is the Mr Burns of Australian politics. He is simply out of touch with the everyday struggles of working Australians.
"Australia has so much potential to become a clean energy superpower and create thousands of jobs with the federal government's Future Made in Australia plan. Instead, we have an Opposition Leader who is obsessed with playing politics with the lives of workers and taking Australia backwards."

Scientists

Proposals to introduce nuclear power to Australia lack support among leading scientists: Australia's Chief Scientist Cathy Foley backs a renewables-led path to net zero emissions over nuclear power, stating that nuclear power is "expensive" and "it would take some time to build up the capability" to introduce nuclear power.[427]

Former Australian Chief Scientist, Alan Finkel, previously a proponent of nuclear power, now says that nuclear power is "too slow and too expensive" for Australia.[428]

Another former Australian Chief Scientist, Robin Batterham, says that: "To reduce renewable targets in the belief that nuclear will be deployed later at scale would create a material risk of not achieving net zero, or doing so at an excessive cost."[429]

NSW Chief Scientist Hugh Durrant-Whyte says that it would be "naive" to think a nuclear power plant could be built in Australia in less than two decades.[430]

Australia's leading scientific organisation CSIRO says that nuclear power "does not provide an economically competitive solution in Australia" and could not be deployed "within the timeframe required."[431]

The Climate Council – including leading climate scientists – states that nuclear power plants "are not appropriate for Australia – and never will be", that nuclear power is "expensive, illegal, dangerous and decades away", and that "we do not need distractions like nuclear to derail our progress" towards a renewable-powered future.[432]

[427] https://www.abc.net.au/news/2024-03-19/chief-scientist-cathy-foley-nuclear-expensive-backs-renewables/103602312
[428] https://reneweconomy.com.au/finkel-australia-can-still-reach-its-82-pct-renewables-target-by-2030/
[429] https://reneweconomy.com.au/energy-experts-says-chasing-nuclear-would-likely-stop-australia-reaching-net-zero/
[430] https://www.skynews.com.au/australia-news/will-be-starting-from-scratch-report-paints-grim-picture-of-australias-long-road-to-nuclear-power/news-story/dec9f44aed1e82c65f224bb5dd34a959
[431] https://www.csiro.au/en/news/all/articles/2023/december/nuclear-explainer
[432] https://www.climatecouncil.org.au/nuclear-power-stations-are-not-appropriate-for-australia-and-probably-never-will-be/

A 2024 report by the Australian Academy of Technological Sciences and Engineering notes that no small modular reactors exist in any OECD countries and the technology has not been proven technically or financially.[433]

14. IS NUCLEAR POWER EXPANDING GLOBALLY?

Much of the pro-nuclear commentary in Australia claims that nuclear power is expanding globally. It is not.

The World Nuclear Industry Status Report 2024 (WNISR-2024) notes that as of 1 July 2024, a total of 408 nuclear power reactors were operating in 32 countries, 30 below the 2002 peak of 438 reactors.[434]

At the end of 2023, nuclear capacity stood at 365 gigawatts (GW). As of mid-2024, operating capacity reached 367.3 GW, 0.2 GW more than the previous 2006 end-of-year record of 367.1 GW. Nuclear power has been stagnant for the past 30 years and a fleet of mostly young reactors is now a fleet of old reactors. In 1990, the mean age of the global power reactor fleet was just 11.3 years.[435] WNISR-2024 notes that the average age of the world's operating reactor fleet has been increasing since 1984 and stands at 32 years as of mid-2024, up from 31.4 years in mid-2023.

As the rate of closure of ageing reactors increases, it will become increasingly difficult for the industry to maintain its 30-year pattern of stagnation by matching closures with start-ups, let alone achieving any growth. Former World Nuclear Association executive Steve Kidd spoke to this problem in 2016, noting that "the industry is essentially running to stand still."[436]

In 2023, WNISR-2024 notes, there were five reactor start-ups (5 GW) and five permanent closures (6 GW) with a net decline of 1 GW in capacity. (This year has also been underwhelming: a net gain of 2 GW of nuclear capacity[437] compared to several hundred GW of new renewable capacity.)

WNSIR-2024 provides further information:
* Nuclear's share of global electricity generation declined from 9.2 percent to 9.1 percent in 2023, little more than half of its peak of 17.5 percent in 1996.
* In the 20 years from 2004 to 2023, there were 102 startups and 104 reactor closures worldwide. Of these, 49 startups were in China with no closures. Outside China, there has been a net decline of 51 reactors over the same period, and net capacity declined by 26.4 GW.

[433] https://www.atse.org.au/what-we-do/strategic-advice/small-modular-reactors-the-technology-and-australian-context-explained/
[434] https://www.worldnuclearreport.org/World-Nuclear-Industry-Status-Report-2024
[435] https://www.worldnuclearreport.org/IMG/pdf/wnisr2023-v1-hr.pdf
[436] http://www.neimagazine.com/opinion/opinionafter-cop-21---where-does-nuclear-stand-4770510/
[437] https://pris.iaea.org/PRIS/

* As of mid-2024, 59 reactors were under construction worldwide, 10 fewer than in 2013. China had the most reactors under construction (27) but none abroad. Russia dominates the international market with 26 units under construction as of mid-2024, six of them in Russia and 20 in seven other countries. WNISR-2024 states: "It remains uncertain to what extent these projects have been or will be impacted by sanctions imposed on Russia and other consequential geopolitical developments following Russia's invasion of Ukraine."
* Construction started on six reactors in 2023 – down from 10 in 2022 – including five in China.
* Chinese and Russian government-controlled companies launched all 35 reactor constructions in the world from December 2019 to mid-2024. Besides Russia's Rosatom, only France's EDF is currently building nuclear power plants abroad (two reactors in the UK) as lead-contractor.

Opposition leader Peter Dutton claims that "50 countries are exploring or investing in next-generation nuclear technology for the first time."[438] In fact, over the 33-year period from 1991–2024, only five countries started up their first power reactors – China (1991), Romania (1996), Iran (2011), UAE (2020) and Belarus (2020).[439] Over 80% of the world's countries have never operated nuclear power plants (158/195 countries or 81%). There will not be a flood of nuclear 'newcomer' countries (only three potential newcomer countries have reactors under construction), and the number of newcomer countries may struggle to exceed the number of countries exiting nuclear power.

WNISR-2024 notes:
* Just three potential nuclear newcomer countries have reactors under construction as of mid-2024: Egypt, Bangladesh and Turkiye.
* Only three countries — China, India, and Russia — are building reactors at more than one site.
* The number of countries building reactors fell by three from mid-2023 to mid-2024. Reactors are under construction in 13 countries, down from 16 countries the previous year as the UAE and the US completed their last construction projects and Brazil suspended its only reactor construction project.

Nuclear vs renewables

Total investment in non-hydro renewable electricity capacity in 2023 was estimated by Bloomberg New Energy Finance (BNEF) at $US623 billion, up 8% compared to the previous year. According to a WNISR estimate, this represents 27 times the reported global investment decisions for the construction of nuclear power plants of about $US23 billion for 6.7 GW.[440]

WNISR-2024 states:
* BNEF estimated investments in stationary storage capacity at around US$36 billion in 2023, which, for the first time, exceeded investments into new nuclear. Globally, utility-

[438] https://www.afr.com/policy/energy-and-climate/the-case-for-a-nuclear-powered-australia-20240312-p5fbnf
[439] https://www.worldnuclearreport.org/The-World-Nuclear-Industry-Status-Report-2022-HTML.html
[440] https://www.worldnuclearreport.org/World-Nuclear-Industry-Status-Report-2024

scale storage additions jumped from just over 10 GW added in 2022 to more than 25 GW in 2023.
* In 2023, annual additions of solar and wind power grew by 73 per cent and 51 per cent, respectively, resulting in nearly 460 GW of combined new capacity, according to the International Renewable Energy Agency.
* The solar PV market saw China alone adding around 217 GW — a 150-percent increase over 2022-additions — and the rest of the world 129 GW for a total of 346 GW or about 1 GW per day.
* The Global Wind Energy Council reported a record of 117 GW of new wind installations, a 50 per cent year-on-year increase, with China accounting for 65 percent of total added onshore capacity and 58 per cent of total added offshore capacity. These numbers compare with a net addition of 1 GW nuclear capacity in China and a global decline of 1 GW in 2023.
* WNISR 2024 states: "In 2021, the combined output of solar and wind plants surpassed nuclear power generation for the first time. In 2023, wind and solar facilities generated 50 percent more electricity than nuclear plants. Wind power alone generated 2,300 terawatt-hours (TWh) and is getting close to nuclear's 2,600 TWh. Since 2013, non-hydro renewables added 3,500 TWh to the world's power generation, 14 times more than nuclear's roughly 250 TWh, and generated 80 percent more power than nuclear in 2023."
* In 2023, the European Union achieved its largest renewable capacity additions ever and the renewable share in total electricity generation reached a record 44 percent. Solar and wind plants together produced 721 TWh compared to nuclear's 588 TWh. For the first time ever, non-hydro renewables generated more power than all fossil fuels combined in 2023 in the EU. Fossil fuel power generation dropped by a record 19 percent, reaching its lowest level ever and accounting for less than one-third of the EU's electricity generation.
* In China, solar PV produced a total of 578 TWh of electricity in 2023, 40 percent more than nuclear's 413 TWh. Wind power generation first exceeded nuclear in 2012: in 2023, wind produced 877 TWh, more than doubling nuclear generation. Adding other non-hydro renewables like biomass to solar and wind, the net total generation of 1,643 TWh in 2023 was four times the nuclear output.

While nuclear power has been stagnant for more than 20 years, renewable energy is growing strongly around the world. In 2023, nuclear power suffered a net loss of 1.7 gigawatts (GW) capacity, while renewable additions amounted to a record 507 GW – record growth for the 22nd consecutive year. Nuclear power accounts for a declining share of global electricity generation (currently 9.1%) whereas the renewables share has grown to 30.2%. The International Energy Agency expects turbocharged growth in the coming years with renewables reaching 46% by 2030.[441] Renewable energy sources currently generate over three times more electricity than nuclear reactors, and will likely generate five times more by the end of the decade.

[441] https://www.iea.org/reports/renewables-2024/executive-summary

15. THE COALITION'S ENERGY POLICY WILL INCREASE GREENHOUSE EMISSIONS

There is no doubt that the Coalition's energy policies will increase Australia's greenhouse emissions since it involves greater use of natural gas for electricity generation, a reduction in renewables (compared to current growth trajectories and targets, the possibility/probability of prolonging the use of coal, in addition to the plan to build nuclear reactors.

The Coalition:
* Opposes the federal government's target of 82% renewables by 2030.[442]
* Opposes the government's target to cut emissions by 43% by 2030.[443]
* Intends to void contracts signed by the Commonwealth in its Capacity Investment Scheme.[444]
* The Nationals are calling for a moratorium on the rollout of large-scale renewables.[445]
* There are concerns that a Coalition government would abandon Australia's legally binding 2030 target under the Paris Agreement, adopted by 196 countries at the UN Climate Change Conference in 2015.[446]
* At the December 2023 COP28 UN climate conference, the Labor government joined 120 countries in backing a pledge to triple renewable energy and double the rate of energy efficiency by 2030[447] – a pledge opposed by the Coalition.[448]
* A Coalition government would however sign Australia on to a pledge supported by just 22 countries to triple nuclear power generation by 2050.[449]

As discussed in section 9 of this submission, the Coalition's nuclear plan might result in somewhere between 6–20 GW of nuclear capacity by 2050. That would equate to 2–7% of total capacity for the National Electricity Market. The reasoning for the argument that net zero by 2050 is impossible without nuclear power remains unclear.

CSIRO states:[450]
"GenCost found nuclear power to be more expensive than renewables and estimated a development timeline of at least 15 years, including construction. This reflects the absence of

[442] https://www.theguardian.com/australia-news/2023/dec/10/coalition-tells-cop28-it-will-tback-tripling-of-nuclear-energy-if-peter-dutton-becomes-prime-minister
[443] https://www.smh.com.au/politics/federal/nationals-nuclear-climate-policy-puts-australia-s-paris-deal-in-doubt-20240424-p5fm8p.html
[444] https://reneweconomy.com.au/nationals-threaten-to-tear-up-wind-and-solar-contracts-as-nuclear-misinformation-swings-polls/
[445] https://www.theage.com.au/national/dutton-s-nuclear-option-condemns-us-to-pricey-power-and-blackouts-20240306-p5fa99.html
[446] https://www.smh.com.au/politics/federal/nationals-nuclear-climate-policy-puts-australia-s-paris-deal-in-doubt-20240424-p5fm8p.html
[447] https://www.theguardian.com/australia-news/2023/dec/03/australia-backs-cop28-renewables-pledge-as-chris-bowen-calls-for-international-emissions-reduction-push
[448] https://www.theguardian.com/australia-news/2023/dec/10/coalition-tells-cop28-it-will-tback-tripling-of-nuclear-energy-if-peter-dutton-becomes-prime-minister
[449] https://www.theguardian.com/australia-news/2023/dec/10/coalition-tells-cop28-it-will-tback-tripling-of-nuclear-energy-if-peter-dutton-becomes-prime-minister
[450] https://www.csiro.au/en/research/technology-space/energy/gencost

a local development pipeline, additional legal, safety and security requirements, and stakeholder evidence. Long development times mean nuclear won't be able to make a meaningful contribution to achieving net zero emissions by 2050."

Quantifying the likely increase in greenhouse emissions under the Coalition's policies is difficult because of the lack of detail provided by the Coalition. Nonetheless, a number of reports and articles have attempted to calculate the impacts and they are summarised below.

In a June 2024 article, George Wilkenfeld and Clive Hamilton summarise their research.[451] At the time, the assumption was that the Coalition planned to build just one reactor at each of the seven targeted sites. Wilkenfeld and Hamilton stated:
"To achieve zero emissions from electricity by 2050 while freezing large scale renewables at the 2027 level would require much more nuclear generation than proposed by the Coalition …. In fact, it would require over four times as much nuclear generation to come online by 2050. It is clear from this analysis that the Coalition's announced plan for nuclear power and its continued commitment to net zero emissions by 2050 are nowhere near compatible. Either much more nuclear energy is needed or the commitment to net zero must be abandoned."

Wilkenfeld and Hamilton go on to note that to bridge the gap with nuclear would require a highly improbable nuclear build-rate:
"We now show that achieving net zero by 2050 through the roll-out of nuclear energy is virtually impossible. "To reach zero electricity emissions by 2050 Australia would need to achieve, from scratch, a better build rate than Japan achieved some time after it had already commissioned its first reactor, with roughly a fifth of Japan's population and industrial capacity. In fact, for its population size, Australia would need to exceed the highest nuclear build rates ever achieved."

Finally, Wilkenfeld and Hamilton estimate increased greenhouse emissions based on various scenarios:
"Even if it were possible to replace fossil fuels with enough nuclear to reach zero emissions from electricity by 2050, emissions in the intervening years would be nearly 54 per cent higher than under the renewables pathway. …
"The Coalition's nuclear strategy would increase Australia's cumulative emissions over the period to 2050 by at least 1,462 Mt CO2-e compared with the renewables pathway This is equivalent to nearly 3.4 times Australia's total annual emissions (433 Mt CO2-e in 2022)."
Their conclusion:
"Our analysis shows that the Coalition's nuclear strategy, if it met its stated aims, would see nuclear plants account for approximately 12 per cent of total electricity generation by 2050.
"The slowed pace of the renewables roll-out implied or stated by the Coalition would result in renewables supplying 49 per cent of total supply (compared with 98 per cent under Labor's plan) and gas generation supplying approximately 39 per cent (compared with 2 per

[451] https://reneweconomy.com.au/australia-will-not-come-close-to-net-zero-by-2050-under-coalitions-nuclear-plan/

cent under Labor's plan). It would have a severe negative impact on the renewables industries, but would be a major boost to the gas industry.
"With high continued supply of electricity from gas under the Coalition's plan, attaining net zero emissions by 2050 would be out of the question. Attaining net zero by 2050 would require four times as many nuclear power plants to be built in the 2040s as the Coalition currently plans.
"Under Labor's renewables plan, Australia's electricity emissions are expected to decline year on year until they reach almost zero on 2050. Under the Coalition's plan for nuclear power, a declining emphasis on renewables and an unavoidably greater role for fossil fuels means emissions from the electricity sector in 2050 would be nearly 19 times higher than under Labor's plan."

A June 2024 report released by Solutions for Climate Australia was released prior to the Coalition's June 19 announcement that seven sites would be targeted for nuclear reactors.[452] The analysis was based on public statements from Coalition leaders Peter Dutton, Ted O'Brien and David Littleproud, including: a halt to utility-scale renewable energy projects; continuing to roll out rooftop solar; and using gas-fired electricity to cover the gap between coal closing and the proposal for nuclear reactors to come online. The report found:
* The impact on climate change of attempting to adopt nuclear reactors in Australia would be the equivalent of emitting double the 2022 annual emissions of the resource state of Oman, every year for the next 25 years.
* That equates to an additional 2.3 billion tonnes of climate emissions between now and 2050 when compared to the Australian Energy Market Operator's Integrated System Plan 'Step Change Scenario' that models the most likely energy transformation scenario under current policy settings.

A Bloomberg New Energy Finance report found that a nuclear-powered Australian economy would result in higher-cost electricity and would "sound the death knell" for decarbonisation efforts if it distracts from renewables investment.[453] Even if nuclear is successfully implemented in Australia it would be 'at least four times' more expensive than average cost of renewables, according to Bloomberg. Taking existing nuclear industries in western nations into account, the cost of nuclear power would be "at least four times greater than the average" for Australian wind and solar plants firmed up with storage today, Bloomberg said.

Research by Sven Teske, Research Director, Institute for Sustainable Futures, University of Technology Sydney, finds that Australia's 'carbon budget' may blow out by 40% under the Coalition's nuclear energy plan.[454] Assoc. Prof. Teske states:

[452] https://docs.google.com/document/d/1wBBBmycW3GzFtx2FsgmAf4_oM0-ysibekCUVUNf8I0U/edit?usp=sharing
https://www.solutionsforaustralia.net/news/nuclear-reactors-a-disaster-for-climate
[453] https://www.theguardian.com/australia-news/article/2024/jun/28/nuclear-energy-report-australia-expensive-decarbonisation-renewables
[454] https://theconversation.com/australias-carbon-budget-may-blow-out-by-40-under-the-coalitions-nuclear-energy-plan-and-thats-the-best-case-scenario-233108

The Coalition's pledge to build seven nuclear reactors, if elected, would represent a huge shift in energy policy for Australia. It also poses serious questions about whether this nation can meet its international climate obligations.

If Australia is to honour the Paris Agreement to limit global average temperature rise to 1.5˚C by mid-century, it can emit about 3 billion tonnes, or gigatonnes, of carbon dioxide (CO_2) over the next 25 years. This remaining allowance is what's known as our "carbon budget".

My colleagues and I recently outlined the technological options for Australia to remain within its carbon budget. We did this using a tool we developed over many years, the "One Earth Climate Model". It's a detailed study of pathways for various countries to meet the 1.5˚C goal.

So what happens if we feed the Coalition's nuclear strategy into the model? As I outline below, even if the reactors are built, the negative impact on Australia's carbon emissions would be huge. Over the next decade, the renewables transition would stall and coal and gas emissions would rise – possibly leading to a 40% blowout in Australia's carbon budget. …

Using the One Earth climate model, I calculated two scenarios of how the policy would affect Australia's carbon emissions until 2050. These calculations have not yet been peer-reviewed, but are based on an established modelling tool and publicly available information.

Under the first scenario, the Coalition's seven nuclear reactors are built and operating by 2040 (bearing in mind this timeframe is highly unlikely to be achieved). The reactors would have a total capacity of about 6.5 gigawatts and produce about 50 terrawatt hours of electricity.

Let's say Australia wants to stay within its carbon budget of 3 billion tonnes of CO_2 emitted in the three decades to 2050. Would this be achieved under the nuclear plan? The results produced by our model suggest the clear answer is no.

It shows with nuclear in the mix, Australia's total emissions would rise from 3 billion tonnes to 4.2 billion tonnes – blowing our 2050 carbon budget by 40%.

This assumes two 0.5 gigawatt gas power plants are built by 2030 and another two of the same capacity by 2040. It also assumes the capacity of existing coal-fired power of 16 gigawatts in 2030, 10 gigawatts in 2035 and 5 gigawatts in 2040. The Australian Energy Market Operator expects Australia's entire coal fleet will be retired by 2038. So this scenario would require extending the life of coal plants.

Under the second scenario, Australia realises nuclear energy is totally unfeasible, and from 2035 reverts to Plan A: an economy powered mostly by renewable energy. But during that lost decade, Australia's rate of renewable electricity generation stagnates.

In this case, according to the modelling, the delay would cause Australia to blow its carbon budget by more than 100% by 2050 – emitting a total of 6.7 billion tonnes of CO_2.

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