Submission prepared by the
Australian Workers' Union (AWU)

Inquiry into Nuclear Prohibition by the Committee for Environment and Planning

Submission from

AUSTRALIAN WORKERS' UNION

28 FEBRUARY 2020

About the Australian Workers' Union.

The Australian Workers' Union ('AWU') is the nation's oldest union, and also one of the largest. The AWU has wide coverage in many blue-collar industries, such as steel, aluminium, chemicals, plastics and building materials manufacturing, oil and gas extraction and processing, metal ore mining, agriculture and civil construction.

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Solving the energy crisis

Australia needs to swiftly reduce energy prices and carbon emissions. At present, both challenges remain unaddressed by coherent policy. The AWU believes nuclear power could help address these challenge by lowering the emissions profile of Australia's energy generation sector as well as providing support to the broader efforts to decarbonise by providing firming support to the renewable energy sector. The current bans on the technology mean that Australia – unlike almost all advanced economies – has needlessly removed what could be a useful policy tool in its climate and energy suite.

Rising power prices and unreliability of supply are placing enormous stress on Australia's manufacturing base, putting hundreds of thousands of jobs at risk.

In Victoria, we are witnessing these realities unfold in energy intensive industries such as Aluminium.

With the costs of energy and its economic challenges set to continue, the recent appetite (as inferred by this inquiry and Federal and NSW inquiries) to overcome political obstacles to nuclear energy in Australia is sensible.

The advent of advanced nuclear technologies has made the economics of nuclear energy more attractive.

Both of these factors are explored in the AWU's submission to the federal government's inquiry into nuclear prohibition (see Appendix A).

Addressing public concerns

Unfortunately public anxiety on the dangers of nuclear power is disproportionate to historical evidence and the scientific discipline.

Anti-nuclear advocacy groups have proven extremely successful at fanning public indignation towards nuclear science. This has been achieved by two misnomers: a focus on isolated nuclear disasters, and the linking of electricity generation with the threat of nuclear armament. The conflation of these issues has made it difficult for Australia to have a sensible conversation.

The first is propagated by pointing to nuclear incidents that received widespread public attention.

There have been three major reactor accidents in the history of civil nuclear power; Three mile Island, Chernobyl and Fukishima. One was contained without harm to anyone, the next involved an intense fire without provision for containment, and the third severely tested the containment, allowing some release of radioactivity.[1]

The most publicised is the Fukushima disaster in 2011, whereby a tsunami (which instigated the nuclear disaster) killed approximately 19,000 people. It is worth noting that only one death has since been attributed to the resulting nuclear disaster.[2]

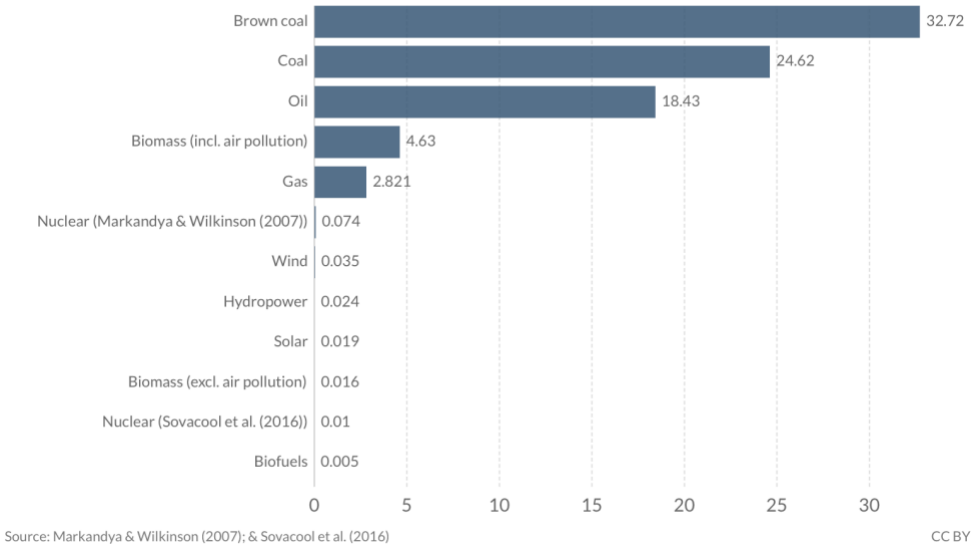
In actuality, peer-reviewed studies that estimate deaths associated with types of energy production shows that nuclear is the safest form of power. Figure 1 shows that some estimates indicate nuclear is the safest form of baseload power generation, and others even safer than renewables.

Whilst any loss of human life is one too many, fatalities associated with other industries is materially greater. As in all industries, ultimately questions of risk and safety should be dealt with under appropriately designed and enforced regulatory regimes.

The second conflation relates to the coupling of nuclear generation and nuclear armament, however neither the physics nor the technologies are the same.[3] The truth is, Australia would not need to build a nuclear power plant to develop nuclear weapons.

Figure 1: Death rates from energy production[4]

[1] https://www.world-nuclear.org/information-library/safety-and-security/safety-of-plants/safety-of-nuclear-power-reactors.aspx
[2] https://time.com/5388178/japan-first-fukushima-radiation-death/
[3] https://thehill.com/blogs/pundits-blog/energy-environment/333329-time-to-stop-confusing-nuclear-weapons-with-nuclear
[4] https://ourworldindata.org/safest-sources-of-energy



The path ahead

The politics of nuclear has become complex and tends to rely on misinformation and emotion. This has created an unusual set of regulatory regimes.

When the Australian government introduced a moratorium on nuclear energy in 1998 and 1999, it was widely acknowledged to be a rhetorical gesture rather than a practicable ban. The reason for this was that irrespective of the legislation, a nuclear reactor could not have been built in Australia without the express support of the government and relevant state government approval.

The Victorian Government's already legislated ban on nuclear activities is a case in point. Without multi-jurisdictional support, as well as regulatory approvals and ministerial discretion, production licences for the extraction of uranium and generation of nuclear power could not be approved.

This is also true of the NSW Government's legislated ban on uranium mining and nuclear in 1986 through the Uranium Mining and Nuclear Facilities (Prohibitions) Act 1986.

Despite having uranium mining bans across all states except South Australia, Australia is the third largest exporter of uranium in the world, set to become second in several years' time. Notwithstanding having a technical ban on uranium mining in Western Australia (WA), there are four uranium mine projects in WA that have just been distributed production licenses.

Since the 1950s there has been a fully operational 20-megawatt nuclear reactor at

Lucas Heights, NSW. Designed for research and industrial uses, the facility nevertheless conducts similar operational activities to that required of a large-scale energy-producing nuclear reactor.

Unfortunately Australia's public policy remains a mess of contradictions. Given the twin challenges of rising energy prices and decarbonisation Australia can no longer afford such policy laziness.

Key Recommendations

1. The Victorian Government acknowledge that nuclear energy is a viable technological proposition that can satisfy Australia's twin needs of competitively providing baseload energy while reducing the overall carbon footprint of the economy. Particular consideration should be given as to how nuclear energy can support a transition to low carbon energy production and the firming of renewable energy generation within the broader system.

2. The Victorian Government engage in consultation with the Federal Government about the cross-jurisdictional legislative obstacles to approving production licenses for uranium mines in Victoria.

3. The Victorian Government lift any regulatory bans on the uranium and nuclear industries which prevent investment and capital allocation decisions being made by private investors and markets.

4. The Victorian Government commence a pilot program to assess the viability of Small Modular Reactors in the Australian economy, with a focus on providing energy to the heavy industrial using businesses in the economy. This should involve liaising with the US Department of Energy to assess the outcomes of the US Government's pilot project.

Appendix A

Inquiry into the prerequisites for nuclear energy in Australia

Submission from

THE AUSTRALIAN WORKERS' UNION

1 OCTOBER 2019

About the Australian Workers' Union

The Australian Workers' Union ('**AWU**') is the nation's oldest union, and also one of the largest. The AWU has wide coverage in many blue-collar industries, such as steel, aluminium, chemicals, plastics and building materials manufacturing, oil and gas extraction and processing, metal ore mining, agriculture and civil construction.

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Prelude

The AWU maintains industrial coverage across all aspects of the Nuclear Fuel Cycle. This includes from when uranium is mined, enriched and manufactured to nuclear fuel, as well as its usage in power plants and the geological disposal or reprocessing of nuclear waste.

The only part of the Nuclear Fuel Cycle that is currently legal and therefore commercial operable is the exploration, mining, and export of uranium product. Workers in this industry are AWU members.

The AWU also maintains significant membership across heavy industrial manufacturing, where baseload electricity power remains one of the largest input costs. This includes the milling and export of steel product, alumina and aluminium, chemicals, fertilisers, and building materials manufacturers.

The topics of uranium mining, nuclear power generation, waste disposal, and spent fuel reprocessing are of interest to the AWU not only for the purpose of creating new and innovative Australian industries, but importantly for preserving job security across our heavy industrial manufacturing sector.

The AWU has had the opportunity to review all publicly available submissions to this inquiry. The AWU has also reviewed domestic and international research published by a range of government and non-government organisations. These include but are not limited to the Australian Government 2006 Prime Minister & Cabinet report into Uranium Mining, Processing and Nuclear Energy, the South Australian Nuclear Fuel Cycle 2016 Royal Commission Final Report, the Canadian Government's Roadmap for Small Modular Reactors, the US Energy Options Network report into the cost of Advanced Nuclear Power Plant Costs, the CSIRO's GenCosts 2018 report, and various materials published by the International Atomic Energy Agency (IAEA), the OECD, and the World Nuclear Association.

In 2015 the AWU made a submission to the South Australian Nuclear Fuel Cycle Royal Commission asserting that the potential economic and employment benefits of the nuclear fuel cycle are vast, and Australian government's should take the necessary steps to support industry growth. It also acknowledged Australia's capacity to manage the safety, environmental and security risks associated with a domestic nuclear industry.

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Executive Summary

KEY AWU RECOMMENDATIONS

1. Acknowledge that nuclear energy is the most viable technological proposition that can satisfy Australia's twin needs of competitively providing baseload energy while reducing the overall carbon footprint of the economy.
2. Take immediate steps to consider the role that nuclear can play in the Australian energy market and emissions reduction targets on both a 2030 and 2050 basis.
3. Commission the Department of Industry to develop a scoping study that will assess the economic, environmental and regional benefits to Australia of a fully-realised, total nuclear life-cycle industry.
4. Immediately lift any regulatory bans on the uranium and nuclear industries which prevent investment and capital allocation decisions being made by private investors and markets. Government policy should seek to encourage and provide investor confidence in the sector.
5. Commence a pilot program to assess the viability of Small Modular Reactors in the Australian economy, with a focus on providing energy to the heavy industrial using businesses in the economy. This should involve liaising with the US Department of Energy to assess the outcomes of the US Government's pilot project.

This report will address the following:

1. Australia's energy challenge.
2. Nuclear energy as the solution.
3. A total uranium industry – Australia's economic potential.
4. Investor confidence in nuclear energy.

Overview

Australia finds itself in the midst of a self-induced energy crisis.

Despite being an energy export superpower, the Australian economy does not have access to abundant, cheap and available energy and electricity inputs. The National

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Electricity Market (NEM) is under stress as it attempts to transition to new, carbon reduced sources of energy inputs without a coherent pathway forward. This lack of planning is creating investment uncertainty and market chaos.

Australia's energy policy is non-sensical at best and destructive at worst. As an energy advantaged country, Australia has traditionally been home to a large slice of global production of energy intensive, commodity manufactures. A lack of transitionary policy has traded away Australia's energy advantage and unnecessarily destroyed existing jobs while losing potential capital investment in these sectors to other jurisdictions.

Australia is the largest global exporter of almost all raw materials and commodities for energy production yet perversely has the highest domestic electricity prices. Despite abundant reserves and large exports of coal, gas, uranium, and lithium, as well as natural endowments of wind, solar, hydro, thermal and wave technology – Australia is unable to satisfy its energy needs.

As Australia transitions over time to a cleaner energy future, nuclear power – facilitated by advances in technology and modularity – can help facilitate this transition while retaining Australia's energy competitiveness.

Due to the current policy vacuum, Australia faces the twin challenge of supplementing baseload power from a retiring coal power fleet, and meeting its internationally obligated emissions reduction targets. Coupled with those challenges, Australia has a manufacturing sector that – due mostly to unaffordable energy prices – is under serious threat.

To preserve Australia's international energy competitiveness and its industrial base – a sector that employs nearly a million Australians in outer suburban and regional areas – the country must urgently address its energy crisis.

As the only viable baseload power source that is emissions free, Australia needs to have a serious conversation about nuclear energy with a maturity that has been absent across the energy debate for over a decade. This is no doubt a significant challenge.

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It is clear from this report that Small Modular Reactor nuclear technology is highly competitive on a pure energy generation basis with the added benefit of being extremely low in carbon emissions.

After coal, and based on the most credible international estimates for SMR LCOE across the world, SMR technologies could provide the cheapest electricity in Australia after coal-fired power generation. That is notwithstanding its baseload and carbon-free benefits.

Another important point to note is that in the event of a carbon price in Australia, the economics of nuclear technology become even more favourable. Even in the absence of a carbon price, and in the event that current subsidies for wind and solar were extended to nuclear, the cost of SMR electricity would be more economical than coal power generation in Australia.

This inquiry has come at a time that several other parliamentary inquiries across the country are considering the merits of expanding nuclear activities in Australia.

Over the last two years the Australian Energy Market Operator has intervened in the National Electricity Market (NEM) five times more than usual. Currently there is no transitional plan to deal with Australia's energy needs. Australia's baseload power generation sector is struggling to cope with the demands placed upon it while renewable technologies are not yet fully developed to provide the deployable needs demanded by the economy. Due to high electricity prices, manufacturers are publicly sending capital investments to developed countries such as the US, where energy is more affordable, costing Australia tens of thousands of jobs and billions in capital investment. If left unaddressed, Australia's energy crisis could lead to mass closures and the loss of hundreds of thousands of highly paid jobs.

With these economic challenges set to worsen, the new appetite to overcome the political obstacles to nuclear energy in Australia is sensible.

To do so, steering the debate in the right direction is more important than ever. For instance, when Australia introduced a moratorium on nuclear energy in 1998 and 1999, it was widely acknowledged to be a rhetorical gesture rather than a practicable ban. The reason for this was that a nuclear reactor could not have been built in Australia without the express support of the government, with regulatory and legislative hurdles that ultimately required government approval.

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The same reasoning applies to the uranium mines across state legislatures. Thus, Australia's history of 'banning' the nuclear industry is one defined by the politics of the day, rather than a consequence of a well thought out and reasoned policy debate.

Fears of nuclear radiation and disasters harness public anxieties to a point where Australians can no longer debate the topic or make decisions based on the evidence.

The facts of course do not bear these fears out. Nuclear energy is a mature, proven and safe power generation technology and is depended on as a critical part of the energy mix in many developed countries across the world. It has resulted in fewer accidents and many fewer deaths and worker injuries than other energy generation sources.[1]

Yet twenty years later since the initial ban, the legislative prohibition on nuclear activity remains.

This ban ignores the enormous technology that the sector has undertaken including – but not limited to – the innovation of small modular reactors. Furthermore the ban prevents the market from choosing how best to efficiently allocate energy investment capital.

The first prerequisite to achieving nuclear power generation in Australia must be to signal to the electorate that the Australian government will no longer support legislation that is predicated on political fear. It would be a powerful statement on Australia's willingness to join the rest of the developed world in adopting advanced technology and using it to support an economy that prides itself on maintaining advanced technical and human capital. It would allow for a sensible debate.

Only then can Australia begin to untangle itself from an energy outlook that holds dire consequences for job destruction across the economy.

[1] World Nuclear Association, Safety of nuclear power reactors, London, 2018

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KEY FACTS

- **Australia has the most uranium in the world** – Australia has the world's largest Economic Demonstrated Resources (EDR) of uranium – 1,270,000 tonnes – which represents around 30% of total EDR of uranium in the world.[2]
- **World sources significant portion of energy from nuclear** – approximately 10 per cent of global electricity production comes from Nuclear energy, driven largely by US, France, China, Russia, South Korea and Canada.[3]
- **World is expanding its dependency on nuclear** – total nuclear energy capacity is set to expand by about 15 per cent as 55 nuclear reactors undergo construction.
- **Australia an exception across the world** – the US, UK, Switzerland, Sweden, South Korea, and Finland each source more of their energy mix from nuclear then Australia does from renewables altogether.
- **Australia could fulfil its emissions reduction targets with nuclear** – If Australia used nuclear generation to the same extent as Sweden, it would have achieved all of its emissions reduction obligations. If it used half of the Uranium it sent to Europe, it would have met the Paris Target several times over.
- **Cost of nuclear in Australia stacks up** – The cost of energy from advanced nuclear technologies in Australia is set to be cheaper than all renewable technologies and gas-powered generators, and in many cases also cheaper than coal.
- **Nuclear Fuel Cycle could bring tens of thousands of jobs** – there are approximately 2100 jobs in Uranium mining in Australia. The jobs in Uranium mining are set to exceed 10,000 over the next decade, and could be several times that with a complete Nuclear Fuel Cycle.

[2] NSW Parliamentary Library, Uranium Mining and Nuclear Energy in New South Wales, Page 53
[3] https://www.world-nuclear.org/information-library/current-and-future-generation/nuclear-power-in-the-world-today.aspx

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1. Australia's energy challenge

As Australia's population continues to expand at a world-leading rate, our nation needs more roads, tunnels, pipelines and buildings. Our ability to securely support the expansion of our nation's infrastructure depends on the strength of our local industries including but not limited to our steelworks, aluminium smelters, building materials manufacturers and processors, and refineries. Despite this, our local heavy manufacturing base is under threat, with the cause indisputable: Australia has become an increasingly uncompetitive place for manufacturing.

It's a sobering reflection as Australia tops the ranks of exporters across the world for iron ore, coal, bauxite, natural gas, uranium, and lithium. We enjoy an abundant supply of raw goods but can't seem to maintain a foothold in their manufacture.

One of the main reasons for our lack of competitiveness is energy: Australia has the highest energy prices in the world.[4]

1.1. How did we get here?

When the National Electricity Market (NEM) was first established in the 1990s, the East Coast of Australia enjoyed some of the cheapest prices for electricity in the world.[7]

Since then, we have benefitted from several mining booms driven by iron and coal exports. Australia discovered so much gas in the ground that it built the first gas export sector predicated solely on unconventional gas in the world. We also found some of the largest deposits of uranium and lithium (inputs for nuclear and battery storage) in the world, and we top the ranks for exporting them too. During this period Australia has enjoyed the longest run of economic expansion ever experienced by a country in recent centuries.

[4] https://www.power-technology.com/features/australia-energy-prices/
[7] https://www.afr.com/politics/australian-households-pay-highest-power-prices-in-world-20170804-gxp58a

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Despite this, between 2009 and 2019 Australia slipped from 29th to 55th in the world when it comes to adequacy and efficiency of energy infrastructure.[8] Over the course of those 10 years, the average household and industrial electricity costs have risen by more than 90 per cent – more than 3 times the rate of inflation.[9]

In 2014 BIS Shrapnel predicted that without adequate government energy policy the looming gas and energy crisis would cost the Australian economy 235,800 jobs.[10] Since then the country has systematically lost opportunities to expand our manufacturing sector to countries with more competitive energy prices.

In 2017 Australia's largest fertiliser and explosives manufacturer, Incitec Pivot, announced a new manufacturing facility in Louisiana, US, citing energy costs as a deterrent to further investment in Australia. In 2019 BlueScope steel – Australia's largest steel manufacturer – passed on spending $1 billion in Australia to expand steel manufacturing capacity for Ohio, US, on account of energy costs.

Coogee Chemicals closed its Laverton plant in Victoria, and is considering investing in a new plant in the United States.

Needless to say, manufacturers' confidence in the Australian market is low, and it has been driven in large part by Australian governments perennial bad strategic decisions on matters of energy policy over the last 10 years. Put simply, Australia's energy policy – or lack thereof – has been disastrous for the manufacturing and industrial sectors.

Australia's energy story reads as one of constant missed opportunities.

Despite being the largest coal exporter, Australia did not build one coal-fired power generator during this time. We became the largest LNG exporter and didn't reserve a single molecule of gas for our own consumption on the East Coast. We became the largest lithium exporter and didn't manufacture one of our own large-scale

[8] https://www.imd.org/wcc/world-competitiveness-center-rankings/world-competitiveness-ranking-2019/
[9] Australian Bureau of Statistics, cat. No. 6401. Consumer Price Index Australia, Jun 2019; cat. No. 6427, Producer Price Index

[10] BIS Shrapnel, 2014, The Economic Impact of LNG Exports on Manufacturing and the Economy

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batteries. And we are one of the largest uranium exporters across the planet, yet still didn't generate one unit of nuclear energy in our overall market mix.

Australia was and remains the first and only country in the world to have introduced a carbon pricing mechanism only then to abolish it.

Despite existential challenges to our manufacturing sector, Australia now finds itself in the unenviable position of transitioning to a zero-emissions future with an energy sector less than capable of delivering affordable baseload energy.

In 2015 Australia signed the Paris Agreement, committing to reducing greenhouse gas emissions from 2005 levels by 26-28 per cent before 2030. Unless Australia can find a way to reduce emissions responsibly without eroding at the affordability of baseload power, we will needlessly destroy hundreds of thousands of manufacturing jobs disappear.

1.2. Working towards a solution

Australia needs baseload power to ensure reliability and affordability within the NEM. It also needs to reduce its dependency on the most significant source of baseload power generation in Australia: coal-fired power.

As 50% less emissions-omitting than coal, gas has for some time been seen as a critical transition energy source toward a low-carbon Australian energy future. Unfortunately, this too as a solution to Australia's energy transition has been squandered by reckless government decision making. The previous federal government's sanctioning of gas exports in the absence of safeguards for the domestic gas market resulted in the quadrupling (or more) of the domestic gas price.

With exorbitantly high gas prices caused by the export crisis, Australia can no longer use its enviable gas reserves as the silver bullet to its energy crisis.

We need to meet our international obligations for emissions reduction whilst also tempering the enormous rise in electricity costs across our country, in an energy market that is becoming more unreliable.

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Nuclear energy can fix all of these challenges simultaneously.

Nuclear energy produces net-zero emissions and more than 33 countries around the world use it as a significant source of baseload energy in their energy mix. With our vast reserves of uranium, Australia would be one of the best placed countries in the world to take advantage of low-cost, abundant, low-emissions nuclear energy.

This inquiry represents a critical opportunity for Australian politicians to begin making the right decisions for our energy future.

Unfortunately, the underpinning Terms of Reference of this inquiry are in many ways emblematic of the paucity of Australia's energy policy debate.

> *'Successive Labor and Coalition governments have maintained a bipartisan moratorium on nuclear electricity generation in Australia. Australia's bipartisan moratorium on nuclear energy will remain in place.'*
>
> **Terms of Reference, The Standing Committee on Environment and Energy, Inquiry into the prerequisites for nuclear energy in Australia 14**

The first prerequisite to having a robust and substantive conversation about the critical challenges ahead for Australia's energy sector – and the role that nuclear may have within it – is to not rule out options before the inquiry has even had a chance to consider all information and options before it.

The AWU urges the Committee to reconsider this unnecessary limitation on its own remit and to broaden the scope of the inquiry to consider the removal of the moratorium.

14 https://www.aph.gov.au/Parliamentary_Business/Committees/House/Environment_and_Energy/Nuclearenergy/Terms_of_Reference

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2. Nuclear as a solution to Australia's energy crisis to the baseload problem

2.1. History of nuclear debate in Australia

Australia has been extracting uranium and producing nuclear power for research for almost half a century.

Australia built its first High Flux nuclear reactor in Lucas Heights, New South Wales in the 1950s. It operated until 2007 when it was replaced with a 20 megawatt Open-pool Australian Lightwater reactor, also based in Lucas Heights. The reactor is primarily used for research in materials science and structural biology, as well as for some medical and industrial applications.

Uranium has been mined in Australia since the 1950s.[17] Home to the single largest uranium deposit in the world, South Australia has also mined uranium since the 1980s. The Olympic Dam mine in South Australia has held the largest share of Australia's uranium product in the country since it began operation in 1988. Since then, another uranium mine was opened in Four Mile in South Australia, and another in Ranger in the Northern Territory. There remains several exploration- and construction-stage uranium mines across the country at varying stages of approval processes.

Despite this, different jurisdictions across the country have legislatively equivocated on matters of nuclear and uranium over the last decade.

- **New South Wales** – the government introduced a ban on uranium mining and nuclear in 1986 through the Uranium Mining and Nuclear Facilities (Prohibitions) Act 1986. The bill made it an offence to prospect for or mine uranium. In 2012 the government introduced the Mining Legislation Amendment (Uranium Exploration) Bill 2012, which removed the uranium *prospecting* prohibition of the original Act. It remains illegal to construct or operate a nuclear reactor for the production of commercial electricity in NSW.
- **Queensland** – the government introduced a legislative ban on uranium mining in 1989. In 2012 the government repealed the ban for uranium

[17] NSW Parliamentary Library, Uranium Mining and Nuclear Energy in New South Wales, Page 53

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extraction which was then reinstated in 2015, whilst still allowing for the prospecting and exploration of uranium.

- **Victoria** – the government introduced a legislative ban on uranium and nuclear activities in 1983 through the Nuclear Activities (Prohibitions) Act 1983, prohibiting both the exploration and production of uranium in the state.
- **Western Australia** – the government has maintained a ban on uranium mining until 2008. In 2017, the WA Government delivered on an election commitment to ban uranium mining but would allow four previously approved projects to proceed. The four projects currently undergoing construction are Kintyre Project, Yeelirrie Project, Mulka Rock Project, and Wiluna Project.
- **Northern Territory** – has maintained no prohibition for uranium mining and has one near-closure uranium mine which is undergoing rehabilitation considerations.
- **South Australia** – maintains no prohibition on uranium mining and has allowed for its extraction since the 1980s.
- **Australia Government** – Mining or milling uranium ore is defined as a 'nuclear action' in Environment Protection and Biodiversity Conservation Act 1999. This means that an EPBC Act approval is required for every uranium mining project by the Federal Government Minister.

Australian governments have also run various assessments and inquiries into matters of uranium mining and nuclear facilities.

Notably, in 2006 the Department of Prime Minister and Cabinet convened a taskforce, chaired by Dr Ziggy Switkowski, to investigate the viability and feasibility of nuclear energy in Australia. At the time the report concluded that Australia was well placed to host nuclear power in its energy mix and proposed that Australia could host 25 nuclear reactors by 2050.[18]

In 2015 and 2016 the South Australian government commenced a Royal Commission into the Nuclear Fuel Cycle, which investigated the preparedness of the state to host all components of the nuclear fuel cycle. The report acknowledged that notwithstanding the jurisdictional constraints to reversing the prohibition of nuclear activities (or asking the federal government to repeal its prohibition) in South Australia, that the state was well placed to host all elements of the nuclear fuel

[18] https://www.abc.net.au/pm/content/2006/s1794145.htm

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cycle. In particular, community support was noted to be the primary inhibitor of expanding our nuclear activities beyond research and uranium extraction.

Australia now finds itself in a unique position where several parliamentary inquiries are reviewing the legislative context and community appetite for aspects of the nuclear fuel cycle. At the time of the Inquiry into the prerequisites for nuclear energy in Australia, held by the Standing Committee for Energy and Environment, the Standing Committee on Industry, Innovation, Science and Resources has also held public roundtables on nuclear energy. The New South Wales government are also currently holding an inquiry into the repeal of the Uranium Mining and Nuclear Facilities (Prohibitions) Bill. In addition, the Victorian government have also announced a 12-month inquiry into the feasibility and suitability of nuclear power.

It's important to note that just recently the WA government reintroduced its ban on uranium mining whilst also sanctioning four projects to proceed. The Queensland government have similarly over the last decade had three different periods with different prohibition statuses on uranium mining.

2.2. The baseload power challenge

Despite the fickle nature of nuclear politics, there is a sense that in 2019 the debate on nuclear and uranium mining has taken on a level of majority not seen previously. In particular the several inquiries and considerations by governments to reassess community appetite for nuclear and uranium mining has been notable.

Part of that reason is that due to its own refusal to consider nuclear historically, Australia faces a uniquely dangerous baseload power generation problem.

In 2017-2018 the National Electricity Market (NEM) generated approximately 73% of its electricity from coal-fired power generators.[19] Needless to say, the NEM's largest and most dependable source for baseload power is coal power generation.

[19] https://www.aer.gov.au/system/files/State%20of%20the%20Energy%20Market%202018%20-%20Chapter%202%20A3%20spread_1.pdf, page 81

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The Australian Energy Market Operator (AEMO) estimates that about 60 per cent of that coal-fired generation capacity will retire by 2040.[21] On this risk, AEMO begins its annual report on the state of the NEM with the following remark:

AEMO… modelling continues to show a heightened risk of unserved energy over the next 10 years, confirming again that additional investment will be required in a portfolio of resources to replace retiring capacity, and that… targeted actions to provide additional firming capability are necessary to reduce risks of supply interruptions.

2018 Electricity Statement of Opportunities, AEMO[22]

Australia's industrial sector needs a large amount of reliable electricity which cannot currently be substituted for renewables and battery technologies. These cannot be replaced by small-scale renewables in the existing grid, and it is unlikely to be replaced in great part by large-scale renewables and/or hydro.

It has been estimated that South Australia's marquee battery could run the Tomago aluminium smelter in Newcastle NSW for a total of eight minutes.[23] There are several other aluminium smelters across the east coast that would suffer a similar fate if baseload power were unavailable in the NEM.

The notion of gas-fired power generation taking a larger part of the baseload power mix is not an unrealistic one, but certainly an increasingly unfeasible one. Due to the closure of significant gas-power generators over the last couple years, coupled with a substantially higher gas price flowing from unrestricted Australian gas exports, gas-powered electricity has become less viable in Australia. This is in stark contrast to countries such as the US and Canada where the shale gas revolution – coupled with export restrictions and reservation policies – has driven ultra-low gas prices, making alternative power generation technologies less competitive.

[21] https://www.industrysuper.com/assets/FileDownloadCTA/2daa2c8217/Modernising_electricity_sectors_a_guide_to_long_run_investment_decisions_FINAL-002.pdf

[22] https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/NEM_ESOO/2018/2018-Electricity-Statement-of-Opportunities.pdf, page 3

[23] https://minister.environment.gov.au/taylor/news/2018/doorstop-matt-howell-ceo-tomago-aluminium

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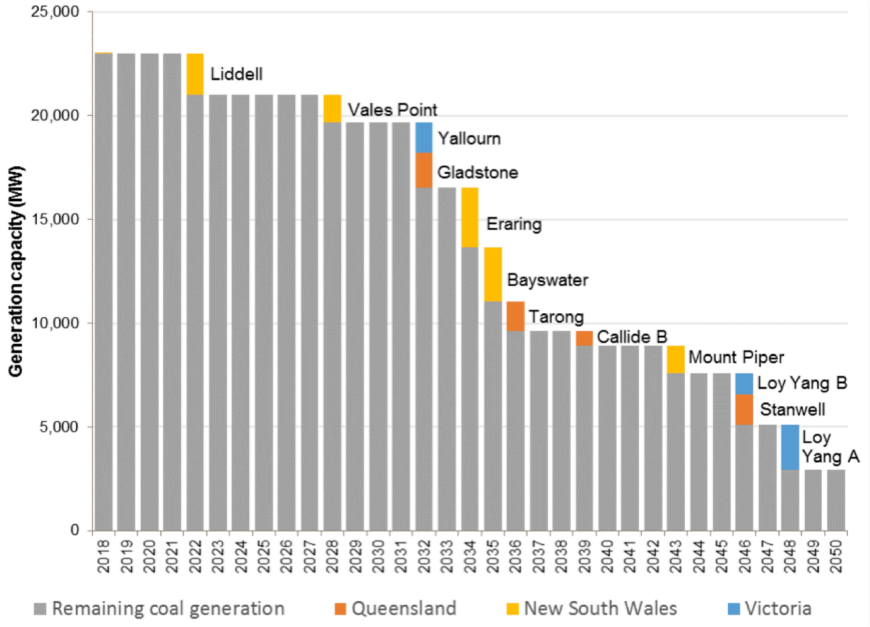
The depletion of baseload power generation in Australia is already causing enormous problems to grid stability and industry viability.

Over the next 30 years Australia's coal-fired power generation is set to retire dramatically. Figure 1 depicts AEMO's closure dates for coal generation in the NEM. As a general deduction, Australia's coal-fired power generation capacity halves approximately every ten years. The critical question is whether new forms of electricity generation – as well as the new market rules and design – will be able to reliably provide electricity to the industrial sector as well as the residential sector.

Figure 1: NEM Coal Generation fleet at plant retirement



Indeed, implications of less baseload power in the electricity market of less reliability and greater intervention by our regulators are already manifesting.

The primary reason for this has been the substantial reduction in coal-fired generation as part of the NEM's energy mix over the last decade.

For instance, a reliable method to assess the vulnerability of our energy system is to observe the number of AEMO directions in the NEM. An AEMO direction is a mandatory instruction made by AEMO to generators and network service providers for system security purposes. If AEMO make more directions in the market, it is intervening to ensure the system does not become unreliable so as to risk a blackout.

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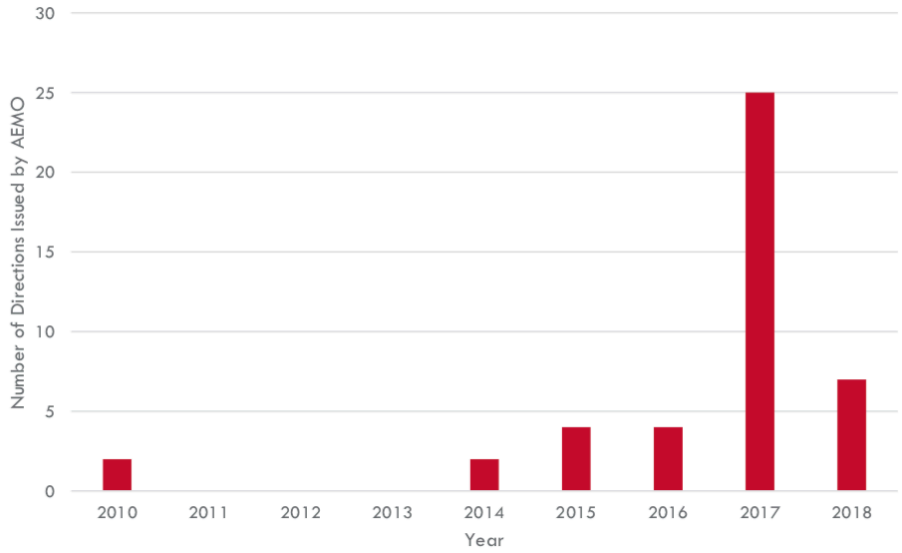
Figure 2 shows the number of AEMO directions in the market increasing by over 500% in 2017, with 2018 figures only accounting for the first two months of the calendar year and already double that of 2016.

Figure 2: Number of AEMO directions in the NEM since 2010 (2018 includes Jan-Feb only)



AEMO acknowledged in their 2018 AEMO Observations report that the NEM is facing increased variability and uncertainty in the resource mix, and the erosion of baseload demand.[28] Specifically, they stated that as the generation mix is changing, it is becoming more challenging to maintain the security and reliability of the power grid.[29]

The substantial increase in AEMO directions, as well as their reasoning for those actions, are an unequivocal fact of the challenges facing the NEM.

An ageing coal fleet – one which is set to retire almost entirely by 2050 – and the increasingly perverted economics of substantially increased gas-powered generation means that Australia's industrial sector will face a very real existential threat over the next decade. Based on current projects the wholesale price of

[28] https://www.aemo.com.au/-/media/Files/Media_Centre/2018/AEMO-observations_operational-and-market-challenges-to-reliability-and-security-in-the-NEM.pdf, page 3.
[29] https://www.aemo.com.au/-/media/Files/Media_Centre/2018/AEMO-observations_operational-and-market-challenges-to-reliability-and-security-in-the-NEM.pdf, page 8

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electricity would be too uncompetitive to retain the majority of heavy industrial manufacturing. This is notwithstanding the risks that unreliability poses to the general population and households.

Australia cannot have the best of both worlds.

A failure to reserve gas that is extracted in Australia and exported off our shores has resulted in our gas advantage becoming a drag on our ability to produce reliable baseload power for industry.

In the absence of a retrospective gas reservation policy, as well as moratoriums on gas exploration, the only option for baseload power in a zero-carbon future and a flailing hydro subsector is nuclear energy.

Persisting with a prohibition on nuclear energy when the technology remains the principle solution to Australia's self-induced energy reliability, affordability and availability problem is ideological at best and economically destructive at worst.

With significant challenges ahead for Australia's baseload power generation, it is no surprise that several government inquiries are simultaneously reassessing the country's ability to broaden its host of nuclear fuel cycle activities.

In June 2019 Industry Super Australia released a comprehensive discussion paper on the future of Australia's energy market, titled 'Modernising electricity sectors: a guide to long-run investment decisions'. The following intimations were made about the future of Australia's energy mix.

> *The future of the energy market in Australia… is to identify the most feasible, cost effective adjustment path over the medium-term. The principle of efficiency suggests that this trajectory will involve adopting a mix of generating capacities.*
>
> *These will include renewable technologies including solar, wind, hydro and battery storage with some pumped hydro… [however]* ***it is difficult to see how these problems can be resolved without some nuclear in the mix and the principles of optimality, fairness and merit would suggest it should not be discounted****.*[30] *(our emphasis)*

[30] https://apo.org.au/sites/default/files/resource-files/2019/06/apo-nid244066-1369116.pdf, page 14

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2.3. The new nuclear technology opportunity

Whilst the baseload power challenge has been a significant proponent of the resurgence in Australia's nuclear debate, so too has new technology made the idea of nuclear activities more attractive.

Traditionally, nuclear reactors have been expensive projects, and many note that to achieve the availability of low-cost nuclear power observed in overseas countries, a market would need to have sufficient scale to achieve it. It has been asserted that Australia's electricity market is not large enough to achieve these economies of scale.

The advent of *advanced* nuclear technologies has instilled an international confidence that heavily-capitalised nuclear infrastructure is no longer the only gateway to accessing nuclear power. These technologies take the form of small nuclear reactors that can provide new sources of reliable and cheap baseload power in a carbon-free world.

Small nuclear reactors are not entirely new technology, having been deployed and used successfully within nuclear submarines by the US, Russia, UK, France, China and India for decades.[31] Referred to as Small Modular Reactors (SMRs), advanced nuclear technologies are therefore best described as an engineering feat rather than as a scientific one.

The promise of SMRs are to produce small-scale nuclear reactors through prefabricated modules at an off-site facility (at large scale), bringing down the capital cost per megawatt hour of nuclear energy. The capital cost of nuclear energy can make up to two-thirds the total cost of producing a unit of energy, and outweighs what would conceptually involve a mild increase in the operational cost of producing nuclear power.

SMRs are also typically designed in such a way that additional modules can be added as more energy generation capacity is required.

The NuScale Project being undertaken in the United States is widely considered to be one of the most advanced and commercially feasible SMR designs in the world.

[31] https://www.abc.net.au/news/2019-08-07/small-modular-reactors-nuclear-explained/11386856

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It has received significant funding support from the US Department of Energy and is liaising with government across the world to consider mass deployment.

After receiving an initial round of funding in 2013 a completion date for 2021 was set. Since then, the date has been moved to 2026, with an expected 12-module plant being fully operable by 2027. If the project proves successful, there is a likelihood that SMRs would be deployable on mass-scale by early 2030s, which is about the forecast period many countries are working towards. It is also about the same time the worst of Australia's baseload power challenges will begin to manifest.

2.4. The nuclear opportunity as a solution to the baseload challenge

A critical question for policymakers is whether the cost of electricity produced from SMRs will be economical for Australia's electricity markets. A further critical question for policymakers is whether the need for baseload power overcomes the appetite for customers to pay a premium on the price of electricity.

Economic feasibility analyses are a critical part of informing any business capital decisions as well as government policy considerations.

The universal metric used to define the cost of electricity is the Levelised Cost of Electricity (LCOE). LCOE represents the present value of the cost of a unit of energy (for instance, kwH) by factoring in the economic life of a power plant, such as the costs of construction and operation.[32] LCOE is a useful metric to compare the costs of different types of energy production against each other.

2.4.1. What is the cost of electricity in Australia?

The Finkel Review – arguably the most revered strategic analysis of Australia's electricity system and its challenges produced over the last decade – released its final report in June 2017. It delivered dozens of recommendations to reform Australia's energy market to ensure there would be enough reliability and security in the NEM to help transition Australia into a carbon-free future.

[32] https://www.energy.gov/sites/prod/files/2015/08/f25/LCOE.pdf

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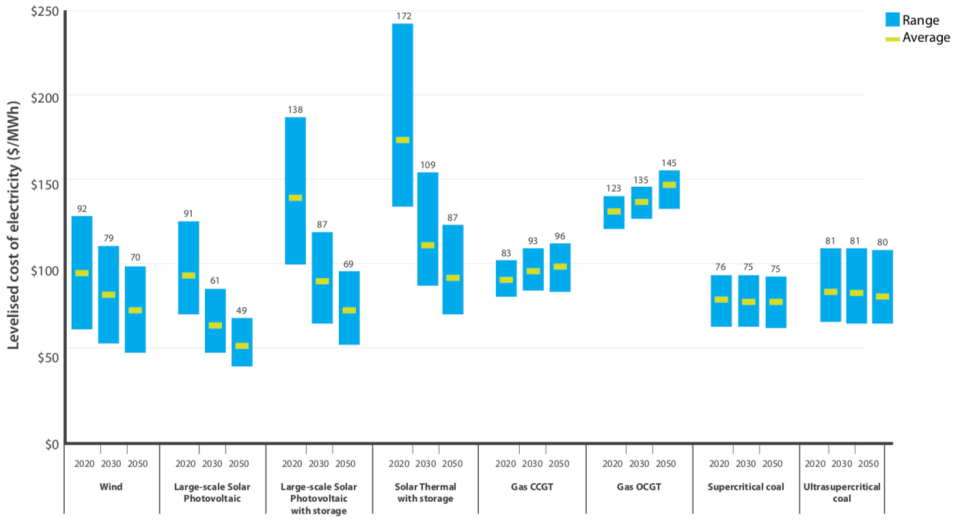
Amidst its workings, the review produced the following LCOE estimates for energy sources in Australia in 2020.

- Wind – $92 / MWh
- Solar – $91 / MWh
- Solar with storage - $138 / MWh
- Gas CCGT - $83 / MWh
- Gas OCGT - $123 / MWh
- Supercritical Coal - $76 / MWh[33]

The review also projected the costs for these energy sources over the next 20 years. Figure 3 shows that for newer technologies such as in renewables and battery storage, the cost of electricity will fall dramatically over the course of the next two decades. The same is likely to be true for nuclear power generation, particularly as dozens of SMRs are set to become operational over several years. Figure 3 also forecasts a stable LCOE for coal-powered generation over the coming decades.

Figure 3: Levelised cost of electricity, Finkel Review



2.4.2. What would be the cost of SMR electricity in Australia?

[33] https://www.energy.gov.au/sites/default/files/independent-review-future-nem-blueprint-for-the-future-2017.pdf, page 201

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In the absence of a commercially operating nuclear energy industry in Australia, it can be notoriously challenging to achieve a reliable set of costs for nuclear energy in Australia. Electricity costs will change depending on regional placement, access to waste facilities, degree of government support (if any), the future pace of coal-fired power phase-out in the NEM, and many other factors.

As such, the most reliable way to estimate the potential cost of SMR electricity in the absence of a clear legislative framework enabling nuclear power would be to compare costs from a cross-section of similar developed-world countries.

United States

An analysis conducted by the US Energy Innovation Reform Project in 2018 is the first advanced reactor cost study informed by vendor-provided estimates, obtained under the provision of non-disclosure agreements. That is, the costs were retrieved from actual business case studies that underpin eight current SMR construction projects.

All of those projects are underway by US companies except one; Terrestrial Energy in Canada. It also included the US NuScale project, touted as one of the most promising SMR projects in the world.[34] The report was able to produced estimates for LCOE of advance nuclear projects, which all use different SMR designs.

The average LCOE across these eight projects was US$60/MWh, which is approximately AUD$80/MWh.[35] Figure 4 shows that approximately two-thirds of the LCOE for SMR technology derives from capital costs, and one-third from the variable costs. It also shows that some LCOE estimates were as low as US$40, or approximately AUD$53/MWh.

Figure 4: Levelised Cost of Electricity for all participating companies, US report.

[34] For instance, see Professor John Quiggin's submission into this inquiry and the recommendation for the Energy Security Board to monitor the progress of the NuScale project.
[35] Using an average AUD:USD exchange rate of 0.75.

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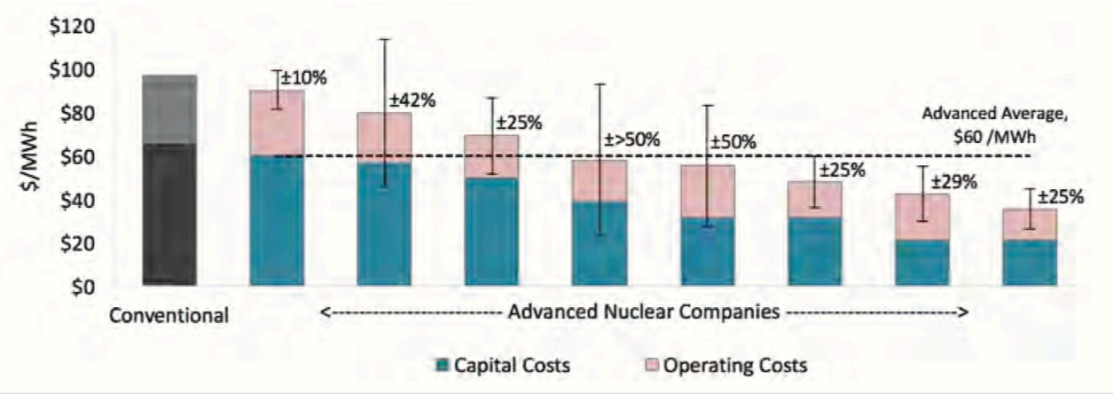
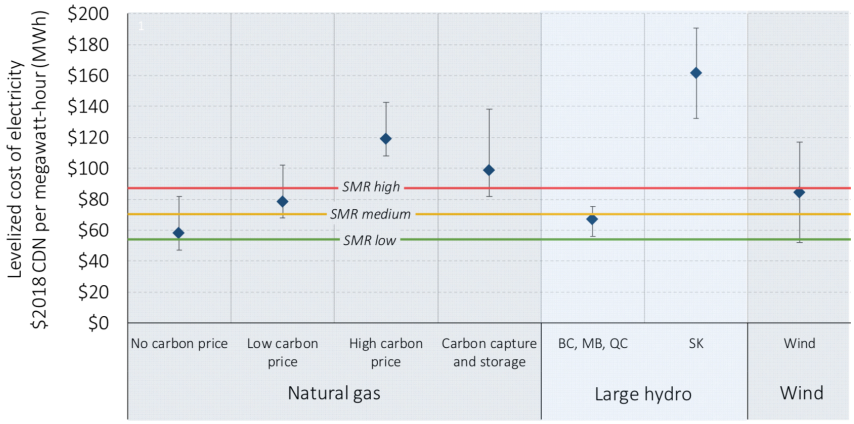


Canada

The Canadian Government produced a substantial analysis on SMRs and their cost in Canada. The report, titled 'A Call to Action: A Canadian Roadmap for Small modular Reactors', assessed cross-jurisdictional imperatives to overcome any obstacles to SMRs in Canada. Importantly, it also weighed the cost of SMRs against gas-powered electricity, hydropower, and wind, under different carbon price scenarios.

Figure 5 shows that the medium LCOE estimate for SMRs was estimated to be CAD$70/MWh, or approximately AUD$77/MWh.[36]

Figure 5: Comparison of levelized cost of electricity from on-grid SMRs with other options, Canadian Government Report.



Organisation for Economic Co-operation and Development (OECD)

[36] Using an average CAD:AUD exchange rate of 1.10.

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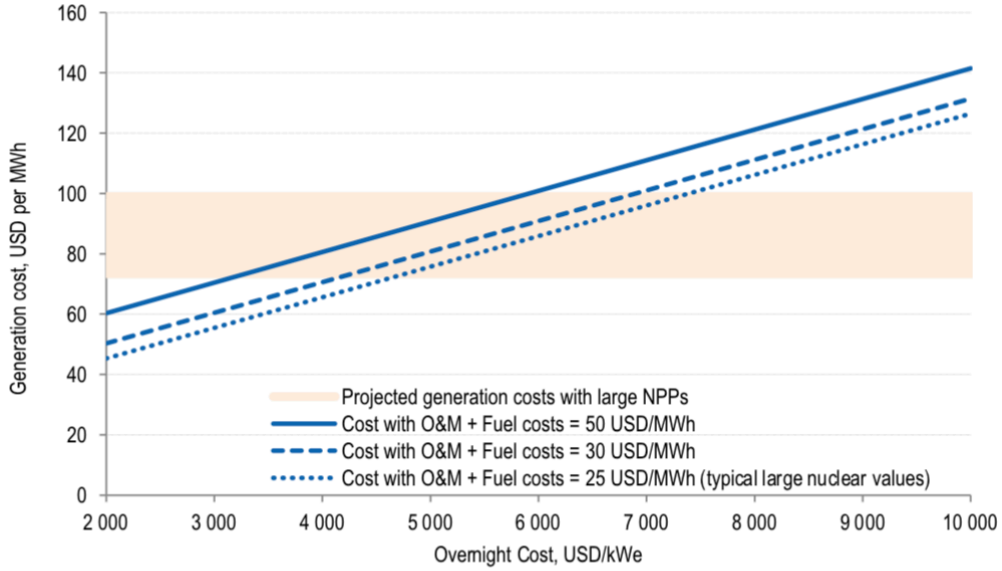
In 2016 the OECD co-published a report, titled 'Small Modular Reactors: Nuclear Energy Market Potential for Near-term Deployment', alongside the Nuclear Energy Agency (NEA).

The report produced LCOE estimates for SMRs using proprietary data from the International Energy Agency and the NEA. As shown in Figure 6, those estimates sit at a threshold of approximately US$60 per MWh, or approximately AUD$80.[37]

Figure 6: Electricity generation cost with SMRs as a function of capital costs, at a 5% real discount rate



Source: Based on information from NEA/IEA, 2015.
Note: Assumed capacity factor is 95%.

Comparing overseas SMR costs with Australia's cost of electricity

The Finkel review estimated Australia's levelised cost of electricity in 2020 across its cheapest source of power – coal power generation – to be approximately AUD$76 MW/h. It estimates gas to be $83 MW/h, and wind and solar to be above $90 MW/h.

[37] Using an averaged AUD:USD exchange rate of 0.75.

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By way of comparison, Figure 7 shows AUD-translated cost estimates for SMR LCOE across overseas government publications.

Figure 7: AWU compilation of LCOE estimates

Source	Levelised Cost of Electricity (LCOE)
US Non-government Organisation	$80/MWh
Canadian Government	$77/MWh
OECD	$80/MWh

The AWU estimates that the LCOE for advanced nuclear technologies in Australia is, based on a review of the literature and accessible business cases, approximately $80/MWh or slightly below. It is important to note that these estimates are for 2020, and not for a future period where it is most likely SMRs could come online in Australia (and quite possibly be cheaper).

It is clear that SMR nuclear technology is highly competitive on a pure energy generation basis with the added benefit of being extremely low in carbon emissions.

After coal, and based on the most credible international estimates for SMR LCOE across the world, SMR technologies could provide the cheapest electricity in Australia after coal-fired power generation. That is notwithstanding its baseload and carbon-free benefits.

Another important point to note is that in the event of a carbon price in Australia, the economics of nuclear technology would become even more favourable. Even in the absence of a carbon price, and in the event that current subsidies for wind and solar were extended to nuclear, the cost of SMR electricity would be more economical than coal power generation in Australia.

2.6. Is nuclear power safe?

Nuclear energy is the safest form of baseload electricity generation.

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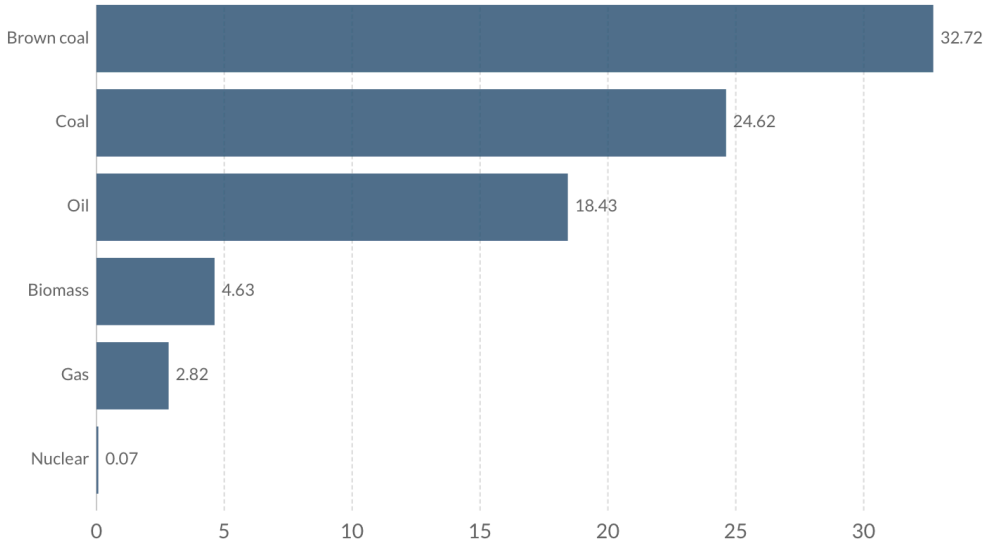
While no amount of workplace fatalities or injuries are acceptable, nuclear energy has resulted in fewer accidents and many fewer deaths and worker injuries than other energy generation sources.[38]

Figure 8 shows that across the globe, fatalities in nuclear power generation equate to 0.01 per cent of the fatalities from coal power generation. data shows that of all baseload sources of energy production, nuclear is the safest technology in the world. Again, these figures should be zero.

Figure 8: death rates from energy production per TWh[39]



Based on this data, one can question how the facts reconcile with public anxieties regarding the industry. High profile cases such as Fukushima in Japan may create an availability bias in the public consciousness. The Fukushima incident was instigated by a natural disaster – in this case an earthquake and tsunami that tragically killed almost 1600 people. Of those lives lost, zero deaths were attributed to the resulting nuclear accident.

Of the Fukushima disaster, the World Health Organisation (WHO) has made the following remark:

[38] World Nuclear Association, Safety of nuclear power reactors, London, 2018
[39] https://ourworldindata.org/what-is-the-safest-form-of-energy

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There were no acute radiation injuries or deaths among the workers or the public due to exposure to radiation resulting from the Fukushima Daiichi NPS nuclear accident.

World Health Organisation[40]

As stand-alone events the impacts of energy-related deaths are large and tragic. However, even as isolated, large-impact events, the death toll from an event stands at several orders of magnitude lower than deaths attributed to air pollution from other traditional energy sources. The WHO estimates that 3 million people die each year from ambient air pollution, and 4.3 million from indoor air pollution.

Unsurprisingly, single events that make headlines overshadow permanent risks that result in more silent tragedies.[41]

Public anxieties on the safety of nuclear power also tend to orient on the disposal of waste.

Nuclear energy creates radioactive waste. Globally, 90 per cent of all nuclear waste is classified low level, with 7 per cent intermediate and 3 per cent high level.[42]

Globally and domestically, the transportation and disposal of nuclear waste is managed safely under a tight set of regulations. Approximately 20 million shipments of radioactive material – mostly for medical purposes – takes place every year.[43]

It is vital to note that there has never been an instance of radioactive release causing harm to people, property of the environment during a shipment of nuclear materials.

Furthermore, Australia is both geologically and geopolitically stable and sparsely populated – making it an ideal candidate for a lucrative waste disposal industry.

2.7. Is nuclear power bad for the environment?

[40] https://www.who.int/ionizing_radiation/a_e/fukushima/faqs-fukushima/en/
[41] https://ourworldindata.org/what-is-the-safest-form-of-energy
[42] World Nuclear Association, What nuclear wastes and how they are managed
[43] https://www.world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-wastes/radioactive-waste-management.aspx

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A unit of electricity produced by nuclear power will create 60 per cent less emissions than a unit of electricity produced by Solar PV.[44]

Nuclear energy produces 16 grams of carbon per kilowatt hour, compared to 46 grams for Solar PV and 12 grams for wind power. It should be noted that these levels of carbon emissions are within the parameters of immateriality. Needless to say, supplementing coal power generation with nuclear power generation is the equivalent, and if not better for the environment, than supplementing it with renewables.

If Australia used nuclear generation to the same extent as Sweden, it would have achieved all of its emissions reduction obligations. If it used half of the Uranium it sent to Europe, it would have met the Paris Target several times over.

France successfully decarbonized the entirety of its energy mix on account of nuclear energy program over 20 years. The UK have recently achieved a final phase-out of coal-powered generation, of which 70 per cent was supplemented with combined cycle gas turbines and nuclear energy.[45]

Nuclear energy therefore remains the only viable baseload power generation in Australia that will be able to help Australia meet its emissions reduction target.

2.8. Nuclear power in other countries

Across the developed world, Australia's relationship with nuclear power is overwhelmingly an exception rather than the rule. Whilst nuclear energy in Australia is banned, other countries have relied on it in the same way Australia relies on coal-power generation.

For instance, France generates more than 75% of its energy mix from nuclear energy, and the UK, USA, Canada, Switzerland, Sweden, South Korea, and Finland each source more of their energy mix from nuclear than Australia does from renewables altogether.[47]

[44] https://www.ipcc.ch/site/assets/uploads/2018/03/SRREN_Full_Report-1.pdf
[45] https://www.afr.com/world/europe/how-britain-ended-its-coal-addiction-20191002-p52wtv
[47] https://www.world-nuclear.org/information-library/current-and-future-generation/nuclear-power-in-the-world-today.aspx, and

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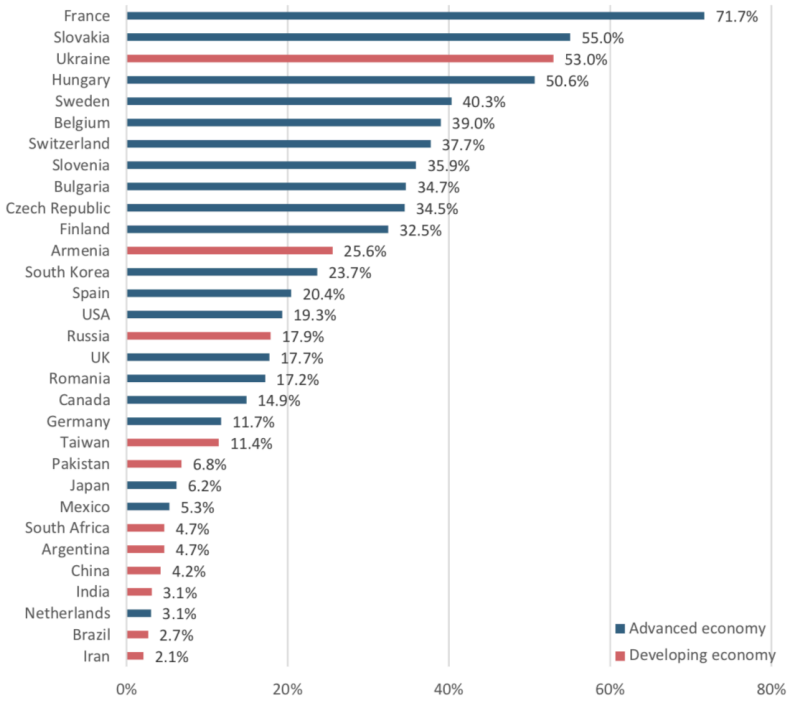
In total, 31 countries rely on nuclear energy in their energy mix, and most developed countries are ironing out legislative pathways to increase their reliance on nuclear amidst the emergence of advanced nuclear technologies.

Figure 9 shows the majority of countries across the world that include nuclear as a significant proportion of their energy mix are developed world countries.

Figure 9: Share of nuclear power in total electricity generation by country, 2018[48]



However, it's not only Australia's reluctance to embrace nuclear energy that makes it unique, but its legislative prohibition on the technology which makes it an even greater exception.

Australia is one of a few OECD countries that maintains a ban on nuclear energy.

The World Nuclear Association describes Australia's reluctance to embrace nuclear as a factor of its coal advantage.53 Given Australia also boasts one of the largest

[48] IAEA, Power Reactor Information System
[53] https://www.world-nuclear.org/information-library/country-profiles/countries-a-f/australia.aspx

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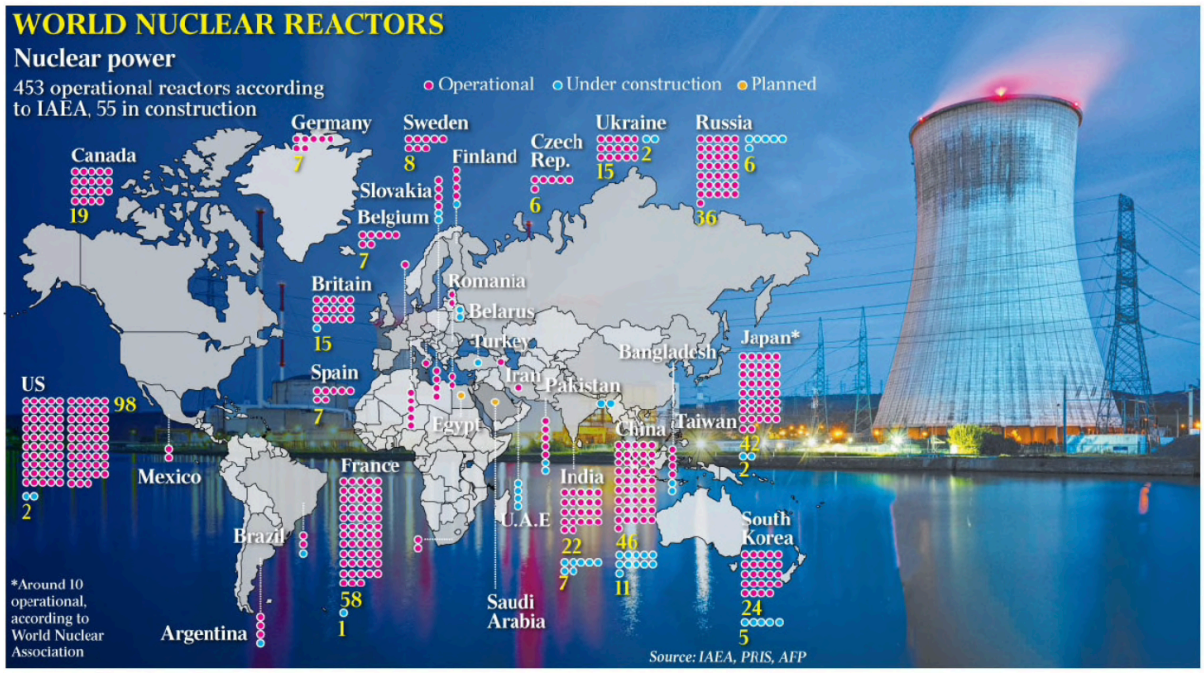
deposits and export volumes of uranium in the world, it seems an unusually ironic and now needlessly damaging position.

Figure 10 shows that there are over 453 nuclear reactors in operation across the world, and that there are 55 in construction. In terms of number of plants, this represents an increase of 12% in total nuclear generation capacity across the world, and more than 15% in terms of actual generating capacity. It should be noted that this is only for nuclear plants currently under construction, and not any of the advanced modularized nuclear technologies that many countries are preparing to embrace over the coming decade.

Figure 10: A snapshot of nuclear power reactors across the world



Many countries are expanding their nuclear power capacity in different ways.

- **United Kingdom** – the UK Government has announced competitions to build the first modular nuclear reactors across the country in effort to mobilise the industry.[54]
- **Canada** – the Canadian government launched a blueprint multi-governmental review into how all levels of government could harmonise

[54] https://www.eti.co.uk/insights/preparing-for-deployment-of-a-uk-small-modular-reactor-by-2030

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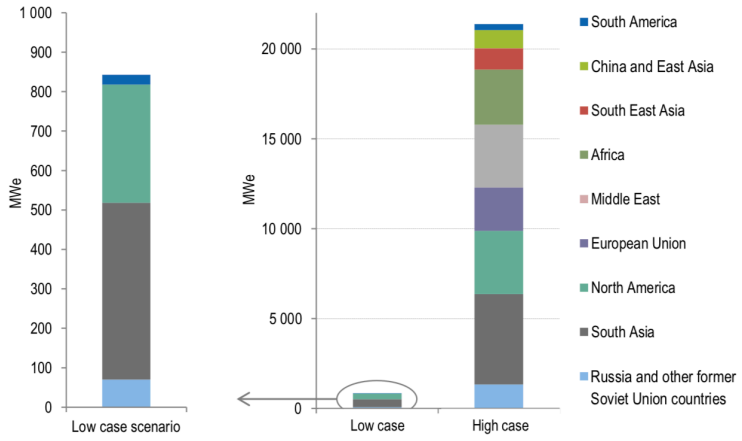
legislation to provide a pathway forward for advanced nuclear technologies.[55]

- **Poland** – whilst it has never had nuclear power generation before, Poland is planning to build a nuclear power plant by 2033 and has released a draft energy policy to support this initiative, envisaging 10% of the country's electricity generation to come from nuclear.[56]
- **United States** – is currently building two nuclear power plants and has undergone similar legislative efforts such as in Canada to pave a pathway forward for advanced modular nuclear technologies.
- **Russia** – in September 2019 completed a build of the world's first sea-borne nuclear power plant to reach regional cities in the north-eastern part of the country.[57]

Despite many different approaches to expanding nuclear capacity across the globe, there is no doubt that SMRs are playing an equally proportionate role in driving that expansion. Figure 11 shows the OECD's estimates for SMR adoption and energy capacity across all continents, where Australia remains the only continent absent from that list.

Figure 11: Estimated SMR Capacity in 2035 by region, OECD/NEA report 2016[58]



A closer look at some of Australia's international peers follows.

[55] https://smrroadmap.ca/wp-content/uploads/2018/11/SMRroadmap_EN_nov6_Web-1.pdf
[56] http://world-nuclear-news.org/Articles/Poland-already-preparing-for-nuclear-plant,-says-e
[57] https://www.reuters.com/article/us-russia-nuclear-floating/russias-first-sea-borne-nuclear-power-plant-arrives-to-its-base-idUSKBN1VZ0CY
[58] https://www.oecd-nea.org/ndd/pubs/2016/7213-smrs.pdf, page 11

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2.5.1 Unites States

The United States is the world's largest producer of nuclear power, accounting for more than 30% of worldwide nuclear generation.

In 2018 the US produced 807 billion kWh of nuclear energy, approximately 20% of total US energy production.[59] It has 98 operating nuclear power reactors in 30 states, operated by 30 different companies.

The average US nuclear generation costs in 2017 were US$34/MWh, or AUD$45/MWh (a remarkably low cost due to the large size of many of their nuclear reactors).[60]

Almost all US nuclear generation comes from reactors built between 1967 and 1990. Until 2013 there had been no new construction starts since 1977, largely because gas generation was considered more economically attractive.

Since 2010 the markedly low natural gas price in the US has continued to undermine the attractiveness of new nuclear energy facilities.

Notwithstanding that, there are now two large nuclear power reactors under construction in Georgia, which began in 2013. There are also a further two planned for construction in Florida.[61] The US is also leading the way for deployment of advanced modular nuclear technologies, with the NuScale project receiving much international appraisal from governments all around the world.

2.5.2 France

France derives approximately 75% of its electricity from nuclear energy. Government policy is to reduce this to 50% by 2035 to diversify its reliance on multiple technologies and replace ageing fleets of nuclear infrastructure.[62]

[59] https://www.world-nuclear.org/information-library/country-profiles/countries-t-z/usa-nuclear-power.aspx
[60] Using an average exchange rate of 0.75.
[61] https://www.world-nuclear.org/information-library/country-profiles/countries-t-z/usa-nuclear-power.aspx
[62] https://www.world-nuclear.org/information-library/country-profiles/countries-a-f/france.aspx

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It has 58 nuclear reactors, and in total produces over 90% of its electricity from nuclear or hydro. The bulk of its nuclear reactors were built in a burst between 1980s and 1990s.

About 17% of France's electricity is from recycled nuclear fuel.

France is the world's largest net electricity exporter, with electricity being the country's fourth largest export. It exports to Italy (which is Europe's largest importer of electricity, coming mainly from France), and the UK.

2.5.2 United Kingdom (UK)

The UK has 15 nuclear reactors which generate 21% of the country's electricity.[63]

In November 2015 the UK government announced a suite of policy priorities, which included the phasing out of coal-fired power generation by 2025, the building of new gas-fired power plants, and a much greater reliance on nuclear power and offshore wind to ensure system reliability.

The UK government has endeavored to revive the UK's nuclear expertise by deploying a range of advanced nuclear technologies.

In July 2016 a UK Parliamentary committee called for the construction of an SMR at the brownfield Trawsfynydd site.

[63] https://www.world-nuclear.org/information-library/country-profiles/countries-t-z/united-kingdom.aspx

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3. The Uranium Industry – Australia's unrealised industry potential

Uranium is the primary fuel used in the production of nuclear power.

Australia has the world's largest Economic Demonstrated Resources (EDR) of uranium – 1,270,000 tonnes – which represents around 30% of total EDR of uranium in the world.[71]

With only 2 fully-commercially operating mines in Australia (commercial activities at Ranger in Northern Territory have subsided dramatically), Australia remains the third-largest producer of uranium in the world (at 6,517 tonnes in 2018), behind Canada (7,001 tonnes in 2018) and Kazakhstan (21,705 tonnes).

A June 2019 report by the department of Industry, Innovation and Science forecast that, with the onset of uranium projects being constructed in WA, Australia's uranium production would increase by approximately 300 per cent over the decade.[72] This would make Australia the second largest producer of uranium in the world.

Australia's current uranium industry employs approximately 2185 people.[73] With estimates to increase this by 300 per cent, and by considering the thousands of construction projects associated with each new project, Australia's uranium industry could employ tens of thousands of people to help design, construct, and operate mines over the next decade. To be clear, those are estimates are predicated on the current legislative framework – that is, almost every state besides South Australia maintaining a prospective ban on uranium mining. A lifting of bans could see these figures great exceed all estimates.

More than half of Australia's uranium exports are shipped to North America (mainly USA), and the EU also purchases a significant portion.

Uranium exports currently generate $675 million in revenue, which has grown by approximately 1.1% over the last five years. Using the Department of Industry's ten-

[71] NSW Parliamentary Library, Uranium Mining and Nuclear Energy in New South Wales, Page 53
[72] Commonwealth Department of Industry, Innovation and Science, Resources and Energy Quarterly, June 2019, p 127.
[73] IBISWorld, Uranium Mining in Australia November 2018.

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year projections, Uranium will be a multi-billion dollar export industry within the next ten years.

When industrialised economies around the world are reducing carbon emissions and expanding carbon-free baseload nuclear power, it seems economically reckless to prohibit what will be a multi-billion dollar export industry by 2030. Some of the benefits expanding uranium export capacity include:

- By increasing uranium supply, Australia is further addressing global greenhouse emission obligations, and offsetting those produced indirectly by its coal exports.
- Australia has robust regulation of uranium mining and conditions for export.
- There is growing demand for nuclear power among Australia's trading partners.
- There is broad-based scientific consensus on the greenhouse has mitigation characteristics of uranium.

Whilst some state government's maintain legislation that prohibit uranium mining and nuclear activities and others don't, the reality is that the government of the day has to authority to approve uranium projects through its environmental approval processes.

Whilst only two states maintain a legislative ban on uranium mining – New South Wales and Victoria – other states with large uranium deposits such as Western Australia and Queensland have had their government's indicate their intention to not allow for any uranium projects to proceed. These are in effect bans on uranium mining.

Notwithstanding that, a prerequisite to taking advantage of the economics of low-cost feedstock for nuclear energy should be to expand our uranium mining industry and consider a legislative framework that ensures a domestic nuclear industry could purchase competitively priced product.

The first step would be for those states with legislative bans to repeal their legislation – as is being considered by both NSW and Victorian parliamentary inquiries – to instill a confidence in the business community that prospecting for uranium is not a frivolous exercise.

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4. The investor confidence prerequisite

The business community will seldom invest in markets when legislative bans are in place for the very product they are looking to produce. Whilst this is true for industries such as uranium mining, it makes sense that it also be true for nuclear activities more generally – such as SMR design and feasibility studies.

The UK Government's Energy Technology Institute (ETI) produced a report in 2016 titled 'Preparing for Deployment of a UK Small Modular Reactor by 2030'. The report's critical recommendation was that to deliver a credible integrated schedule for a UK SMR operating by 2030, their needs to be early investor confidence.[83] It asserted that Government has a crucial role to play in delivering a policy framework which supports SMR deployment and encourages investor confidence.

The report proposes that there are six key pre-construction elements of a UK SMR development program. These are:

- Policy framework supporting project economics
- Capable and credible vendors
- Capable and credible developers
- Investor confidence to progress state-gated investments
- Credible FOAK site amongst a range of deployment sites
- Commitment for UK regulatory assessment (GDA)

The critical takeaway from the list of pre-construction elements of a UK SMR development program are that 50 per cent of them apply to developing investor confidence and attracting capable and credible market participants.

Similarly, the Canadian Government's 2018 report into SMRs argued that investors need policy harmonization across different levels of governments to create investor confidence. It states that 'key enablers, especially industry, end users and investors, consider regulatory clarity and certainty to be a key issue'.[84] It also states that 'the Federal government should implement measures to share risk with private investors, incentivizing first-commercial deployment of SMRs in Canada'.[85]

[83] https://d2umxnkyjne36n.cloudfront.net/insightReports/Preparing-for-deployment-of-a-UK-SMR-by-2030-UPDATED.pdf?mtime=20161011145322, page 3
[84] https://smrroadmap.ca/wp-content/uploads/2018/11/SMRroadmap_EN_nov6_Web-1.pdf, page 16
[85] https://smrroadmap.ca/wp-content/uploads/2018/11/SMRroadmap_EN_nov6_Web-1.pdf, ii

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By reflecting on the UK Government's anxieties of a secure policy framework (even within an already existing nuclear energy industry), the Canadian Government's similar emphasis on ensuring policy harmonization encourages investor confidence, and the Australian Government's legal prohibition on nuclear generation, it can be safely asserted that Australia's policy framework is far from providing the prerequisite confidence to the investor market to begin a conversation.

Needless to say, repealing the Australian government's federal prohibition on nuclear energy should be the most critical step in developing a mature conversation about nuclear technologies with the right expert participants from around the world.

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7 . Conclusion

Over the course of decades and throughout Australia's legislative and political equivocation on nuclear activities, one thing remains true. Almost every leader of the country, and credible expert, has backed the science of nuclear activities.

In the past, this has included emissaries such as Bob Hawke, John Howard, Malcolm Turnbull, as well as current Prime Minister Scott Morrison.

In 2011, current Federal Treasurer Josh Frydenburg published an opinion piece with the following remarks.

> '[Julia Gillard] needs to take the lead and initiate a comprehensive discussion about nuclear power, which happens to be the only carbon-neutral baseload energy source. Failure to do so ignores the informed views of a long list of technical experts, environmentalists and many of Gillard's Labour colleagues'.[86]

In addition, Australia's Chief Scientist Alan Finkel has publicly advocated for nuclear power to help reduce carbon emissions.

> "There are two readily scalable sources of low-emissions electricity: one, solar and wind with storage, and two, nuclear energy… in Australia, the appetite for nuclear baseload is small."[87]

It makes for sober reflection when our most senior scientific experts are the sources of truth for our political obstacles in fixing our energy market.

The critical piece of transitioning to a low-emissions energy mix is in fact a transition, and not a jump.

Therefore the question incumbent on policymakers should not be about what's required to produce nuclear power in Australia's energy mix tomorrow. Indeed, that would be a short-sighted one, ignorant to the many important steps of due process required for significant strategic energy and infrastructure investment decisions made by governments alongside the private sector.

[86] https://joshfrydenberg.com.au/latest-news/nuclear-option-our-safest-bet/
[87] https://www.chiefscientist.gov.au/wp-content/uploads/28-Sept-IAEA-FOR-DISTRIBUTION.pdf

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The question should be whether the science and economics of nuclear power is advanced enough for Australia, and the challenges ahead substantial enough, to justify the political cost of starting a conversation worth having.

The science and economics is in large part substantiated by the many advanced economies that are now embracing nuclear as a solution to baseload power. The challenges are evident, both in AEMO reporting of system unreliability but also the widespread concern over Australia's lack of future energy policy direction, despite fleets of coal-fired power generators forecast to come off line.

The mature conversation about how we can progress can therefore only really begin at the repeal of our legal prohibition of nuclear energy.

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