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Submission to House Select Committee on Nuclear Energy

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Summary

Nuclear energy is a large-scale zero-carbon energy technology already widely used around the world where it provides economically competitive electricity, increased security of supply and reduced carbon emissions.

Australia has the core expertise with nuclear engineering, management and regulatory capability to successfully establish and manage a civil nuclear energy industry. With appropriate investment, this capability can readily be scaled to support a nuclear energy industry in Australia.

Adding nuclear energy to the electricity grid with wind, solar and hydro would increase the reliability and affordability of electrical energy and reduce carbon emissions.

The demand for reliable electricity will increase with increasing population and expanded uses in industry and transport.

Nuclear energy is a viable option for Australia to increase the reliability and stability of our energy system.

The Australian Nuclear Association (ANA) is an independent incorporated scientific institution with members from the professions, business, government and universities with an interest in nuclear science and technology. Many of our members are professional scientists and engineers with considerable experience and expertise in nuclear issues.

The ANA strongly supports establishing a civil nuclear energy program in Australia as part of its future energy mix.

The ANA recommends repealing the bans in federal legislation on nuclear energy to allow a nuclear energy industry to be considered for development in Australia.

The ANA supports an initial phase of selecting a power reactor design that has been licenced and constructed overseas and assessing the suitability of sites of former or current coal plants in Australia. Several identical reactors should be built at one or more sites.

1. Nuclear energy widely used around the world.

Nuclear energy is a large-scale zero-carbon energy technology already widely used in 32 countries where about 440 nuclear power reactors provide economically competitive electricity, increase security of supply and emit very low carbon emissions and other air pollution. https://pris.iaea.org/PRIS/home.aspx.[1]

Since the first commercial nuclear power plants started in the 1950s, there have been more than 20,000 nuclear power reactor-years of commercial operation around the world. [2]

Worldwide, 26 new build nuclear power reactors were added to electricity grids in the past 5 years [2020-2024] [3] and there were 63 nuclear power reactors under construction in October 2024.[4]

Nuclear generated approximately 10% of the world's electricity in 2023.[5]

Nuclear power reactor technology is continually improving and the modern large nuclear plants being built in many countries are proven and very reliable. Australia can gain from overseas experience in the regulation, siting, construction and operation of nuclear power plants in many countries.

On 1 December 2023 at COP28, more than 20 countries launched a declaration to work together to triple nuclear energy from 2020 to 2050.[6] Recognising the key role of nuclear energy in achieving global net-zero, they committed to mobilise investments in nuclear power and to support the development and construction of nuclear reactors.

2. Timeline for nuclear energy in Australia

The time taken to construct a nuclear power plant depends on the type and size of reactor, whether the design is a first-of-a-kind or nth-of-a-kind and whether the design is finalised before construction starts.

Although recent construction of some first-of-a-kind power reactors in Finland, France and the USA (EPR and AP1000 designs) have experienced delays and cost overruns, these countries are actively planning to increase their nuclear energy capacity.

In contrast to the construction delays of the first-of-a-kind EPR and AP1000 reactors in the western world, EPR and AP1000 reactors have been built with much shorter construction time in China and at lower costs than the same design reactors built in Europe and the USA.

The UAE was a country with no nuclear power plants or nuclear industry when its government decided in 2008 to include nuclear energy in its electricity grid. After developing a regulatory regime and assessing options, the UAE ordered four large APR1400 power reactors from the

[1] International Atomic Energy Agency -Power Reactor Information System https://pris.iaea.org/PRIS/home.aspx accessed Oct 2024 .
[2] World Nuclear Energy -Nuclear Reactor Database https://world-nuclear.org/nuclear-reactor-database
[3] https://world-nuclear.org/nuclear-reactor-database
[4] https://pris.iaea.org/pris/
[5] https://ourworldindata.org/nuclear-energy Accessed 31 Oct 2024
[6] https://www.energy.gov/articles/cop28-countries-launch-declaration-triple-nuclear-energy-capacity-2050-recognizing-key

South Korean firm Korea Electric Power Corporation (KEPCO). Construction began in 2012 and these four power reactors are now operating and connected to the grid.

The worldwide mean time from start of construction to grid connection was approximately 10 years for nuclear power reactors completed over the decade 2014-2023. The construction time for new power reactors completed in 2023 were between 7 years and 10.5 years.[7]

3. Costs

The construction cost of nuclear power reactors depends on the type and size of reactor, whether the design is a first-of-a-kind or nth-of-a-kind and whether the design is finalised before construction starts.

Some reactors recently built in the USA and Finland and are being built in the UK and France have been expensive. Despite their experience with these recent high-cost nuclear plants, these countries are actively planning to increase their nuclear energy capacity. Nuclear power reactors built in China, South Korea and United Arab Emirates have been built on time and at much lower costs.

Nuclear power plants for Australia should have identical reactors built in sequence and of a design already built and licensed overseas. It will be important for the Australian nuclear regulator to approve the design before construction starts.

System costs are important when assessing the cost of different technologies for generating electricity. Solar and wind are low-cost generators when they are running but have low-capacity factors and require considerable backup and additional transmission lines which add to the costs of these generators.

Nuclear power plants operate at a high capacity factor – in 2021 the global average capacity factor was 82.4%.[8] This figure would be higher if nuclear power plants were not increasingly being used for load following in response to higher numbers of intermittent generators on the grid. In 2023, the US fleet of nuclear power reactors operated with a capacity factor of 93.15%, compared to 33.5% for wind and 23.3% for solar.[9]

Because of these differing capacity factors, a 1000 MWe nuclear power plant produced more electrical energy than 3500 MWe of solar panels or 2500 MWe of wind turbines.

Decarbonising Australia's electricity system will need an optimum economic mix of clean low carbon technologies to work together.

As quoted in an OECD 2019 study.[10]

"... diversity of energy sources drives down total costs of energy in a low-carbon system, whereas taking options off the table – such as nuclear – creates extra costs to society".

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[7] https://www.statista.com/statistics/1328102/construction-time-for-nuclear-reactors-worldwide/

[8] *World Nuclear Performance Report 2022.* World Nuclear Association, 2022

[9] US Office of Nuclear Energy, *Nuclear Power is the Most Reliable Energy Source and It's Not Even Close* https://www.energy.gov/ne/articles/nuclear-power-most-reliable-energy-source-and-its-not-even-close, Accessed 1 May 2021

[10] The Costs of Decarbonisation: System Costs with High Shares of Nuclear and Renewables, OECD 2019. https://www.oecd-nea.org/jcms/pl_15000

4. Siting

Potential sites for nuclear power plants in Australia include sites of closing coal plants where they can benefit from proximity to the existing grid and a work force experienced in large scale energy facilities.

Australia should follow the international siting standard developed by the International Atomic Energy Agency.[11] Under this standard, the siting of nuclear plants is a rigorous process involving multiple stakeholders and assessment of social licence and technical suitability of sites. It includes outreach programs involving local communities in the decision-making process so as to gain support near potential sites.

Putting nuclear plant near or at locations of retiring coal plants will allow the nuclear plant to benefit from the existing grid connections and an experienced workforce capable of being retained to work at nuclear power plants. The continuity of employment opportunities would be of great benefit to regional communities. Installing nuclear power plants at the sites of retiring coal plants minimises the need for additional transmission lines and are likely to be close to major users of electricity including industrial centres, desalination facilities and other value adding industries.

5. Regulation of nuclear power plants

Australia already has a nuclear regulatory system which can be enhanced to regulate a nuclear energy industry.

The Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) regulates the 20 MW OPAL reactor at Lucas Heights, NSW. ARPANSA's roles could be readily enhanced to regulate nuclear power reactors.

Australian Safeguards and Non-Proliferation Office (ASNO) is responsible for nuclear safeguards and nuclear security. ASNO already regulates the movement of both new and spent fuel from the OPAL reactor and Australian uranium.

The Australian Naval Nuclear Safety Regulator is being established to regulate the nuclear activities relating to AUKUS nuclear powered submarines.

Australia can benefit from the overseas experience in licensing, construction and operation of nuclear power plants.

6. Nuclear energy is clean, zero carbon electricity.

Australia needs access to all available clean zero-carbon technologies, including nuclear energy, to meet the dual challenge of climate change and energy security.

Nuclear energy plays a key role in lowering carbon emissions from the energy sector in many countries. The median carbon emissions for the whole nuclear fuel cycle are very low and of the order of 12 grams CO_2/kWh.[12] This low carbon emission is similar to emissions from wind per unit of electricity produced and less than hydropower and solar PV. This comparison

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[11] Site Evaluation for Nuclear Installations, IAEA Safety Standards Series No. SSR-1. 2019

[12] IPCC, *Emissions of selected electricity supply technologies (gCO2eq/kWh)*. Table A.III.2, Annex III: Technology-specific cost and performance parameters. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change

assumes that methane from hydropower is not significant and ignores the emissions from the construction and operation of any storage or backup generators required for firming wind and solar generators.

Worldwide, nuclear is a major generator of clean energy. In 2023, nuclear power plants around the world produced 16% more clean electricity than wind 60% more than solar but 36% less than hydro.[13]

The use of nuclear power plants enables countries to achieve low carbon emissions from electricity generation. For example, nuclear supplied 65% of electricity in 2023 in France, resulting in France having an overall electrical generation carbon emission intensity of 53 grams CO_2e/kWh in 2023.[14] This compares to 371 grams CO_2e/kWh for its neighbour Germany, which has a similar sized electricity grid, has invested heavily in wind and solar technologies, and has closed its nuclear plants for domestic political reasons.

As well as reducing carbon emissions, nuclear power plants also have small land footprints and perform well in terms of other environmental indicators.[15]

7. Modern nuclear power plants are flexible and can load follow

Nuclear power plants generate dispatchable electricity, i.e. its power can be adjusted on demand by grid operators to match supply with electricity demand.

Variable Renewable Energy (VRE) generators like solar and wind are non-dispatchable because they only generate electricity when the sun is shining or the wind is blowing. The additional cost of storage or standby generators must be included in the cost of electricity from solar and wind, along with the costs of any transmission systems. An electricity grid with large amount of VREs requires many generators to load follow or large amounts of storage to provide backup when the VREs are unable to generate energy.

Most of the modern light water nuclear reactors are capable (by design) of operating in a load following mode and can change their power level once or twice per day in the range from 100% to 50% (or even lower) of the rated power, with a ramp rate of up to 5% (or even more) of rated power per minute[16].

Despite this capability to load follow, most nuclear power plants around the world have been operated as baseload units. This is because the high capital costs and low fuel costs make it more economic to run the nuclear power plants continuously at their rated power level. With increasing amounts of VREs in an electricity grid, nuclear power plants are being designed and built with increased load following capability.

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[13] Our World in Data -*Electricity Production by Source*. https://ourworldindata.org/grapher/nuclear-energy-generation?tab=chart&country=~OWID_WRL . accessed 1 Nov 2024

[14] Electricity Maps https://app.electricitymaps.com/zone/DE accessed 1 Nov 2024

[15] UNECE 2022, *Life Cycle Assessment of Electricity Generation Options*, United Nations Economic Commission for Europe, https://unece.org/sites/default/files/2022-04/LCA_3_FINAL%20March%202022.pdf

[16] Technical and Economic Aspects of Load Following with Nuclear Plants. OECD 2011 https://www.oecd-nea.org/ndd/reports/2011/load-following-npp.pdf

French power reactors can go from 100% rated thermal power to 30% power and return to full power at a rate up to 5% of rated thermal power per minute.[17] A 1,300-MW French reactor can increase or decrease its output by 900 MW within about 30 minutes.[18]

Small Modular Reactors have faster load following capabilities; for example, the NuScale Small Modular Reactor (SMR) module can increase from 20% to 100% power in 96 minutes[19]. The Natrium reactor design uses a molten salt storage system which will take any energy not flowing to the grid. This allows a rapid response and gigawatt hour scale energy storage for many hours.

8. Modern nuclear power plants are safe

Concerns about safety with nuclear reactors are connected directly with perceptions of the disasters at Chernobyl and at Fukushima.

The Chernobyl accident is the only accident in the history of nuclear power generation in which deaths have occurred from radiation. The Chernobyl nuclear power plant type was an old design and would not have been licenced to be built or operated outside the former Soviet Union.

The Fukushima nuclear accident caused great economic loss and evacuation of large numbers of people. No adverse health effects among Fukushima residents have been documented that are directly attributable to radiation exposure from the accident. The estimates of dose are such that future radiation-associated health effects are unlikely to be discernible.[20] For context, it is estimated that the earthquake and tsunami resulted in approximately 18,500 fatalities.[21] Moreover, the location of backup generators water pumps where they were inundated by the tsunami was a serious design fault that could have been so easily avoided.

Nuclear energy is as safe as other low carbon emitting generating sources.[22] Replacing coal generating plants with nuclear in Australia will lead to an improvement in safety and human health due to reductions in air pollution from the continuing operation of coal and gas plants.

As with other high technology sectors like the aircraft industry, nuclear power plant designs are continually being improved based on the operating experience of current nuclear power plants. The nuclear risk and safety of all operating nuclear plant and new designs were reassessed following the Fukushima accident and where necessary upgraded.

A nuclear plant built in Australia would be a modern design that meets international standards, satisfies stringent regulatory conditions and be assessed, approved and licensed by the Australian nuclear regulator before construction.

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[17] IAEA, *Non-Baseload Operation in Nuclear Power Plants: Load Following and Frequency Control Modes of Flexible Operation* Nuclear Energy Series No. NP-T-3.23 2018

[18] Power magazine, 1 April 2019 https://www.powermag.com/flexible-operation-of-nuclear-power-plants-ramps-up/

[19] NuScale, *Ensuring a Balanced Mix with Advanced Nuclear*, 2020, https://www.nuscalepower.com/newsletter/nucleus-summer-2020/featured-topic-cleaner-energy, Accessed 1 May 2021

[20] https://www.unscear.org/unscear/uploads/documents/unscear-reports/UNSCEAR_2020_21_Report_Vol.II-CORR.pdf

[21] https://www.britannica.com/event/Japan-earthquake-and-tsunami-of-2011/Relief-and-rebuilding-efforts

[22] Our World in Data, "What are the safest and cleanest sources of energy? https://ourworldindata.org/safest-sources-of-energy#nuclear-and-renewables-are-far-far-safer-than-fossil-fuels

9. Waste

Australia currently manages low- and intermediate-level radioactive waste from the OPAL reactor and other industrial and medical uses.

As well as low- and intermediate-level radioactive waste a nuclear power program would generate high-level waste.

High-level radioactive waste consists of the spent fuel removed from a power reactor after about 5 years generating electricity. The radioactivity in spent fuel from light water reactors is in a solid ceramic material contained in metal tubes. High-level waste contains both long-lived and short-lived components. The radiation from spent fuel elements is readily controlled by shielding and access limitation.

All countries using nuclear power have facilities for managing all levels of radioactive waste. Experience over many years demonstrates the safe handling and storage of radioactive waste.

Australia already manages a wide range of hazardous wastes including low- and intermediate-level radioactive waste and has the capabilities and resources to manage high level nuclear waste.

Spent fuel assemblies from PWRs and BWRs are stored under water for typically 10 years in a used fuel pond at the nuclear power reactor. The used fuel pond is part of the power plant when it is built. When most of the short-lived radioactivity has decayed after 10 years, the spent fuel assemblies can be moved to dry storage or transported to facilities for processing to remove the residual uranium and other fissile materials for recycling into new fuel.

Dry storage casks are used at many overseas reactors. The casks are round, stainless-steel canisters that hold typically 24 to 72 used nuclear fuel assemblies and placed in concrete casks to control radiation. This means all the spent fuel from 18 months operation (40 to 90 fuel assemblies) will fit into 2 to 4 dry storage casks.

If the spent fuel elements are not to be processed to recover and recycle resources, one option that can be considered is underground disposal in deep geologic facilities. The first such facility in Finland for waste from its power reactors is due to start operations in 2025.[23]

Some countries reprocess the spent fuel from their power reactors to remove enriched uranium and plutonium for reuse as fuel in future reactors. The residual high-level waste can be vitrified into a long-lived glass or converted into a ceramic like Synroc, an Australian-developed technology.

Uranium is a very long lived naturally occurring radioactive material that was mined for the reactor fuel and the radioactivity in the spent fuel has a half-life less than that of the mined uranium. Suitable engineered geologic disposal facilities can be built for high level waste that will be better isolated from the accessible environment than the original uranium ore body.

Nuclear power operators take financial responsibility for waste generated because they are required to set aside funds over the lifetime of commercial operations to cover long term waste management and disposal costs, as well as decommissioning costs. All energy producing technologies produce waste, from the vast quantities of coal ash, the millions of tonnes of waste solar panels and the blades and turbines of wind farms. By comparison, nuclear waste is far smaller in volume and is effectively and safely managed.

[23] https://www.world-nuclear-news.org/articles/test-elements-used-in-trial-run-of-finnish-repository

10. Recommendations

The Australian Nuclear Association (ANA) strongly supports establishing a civil nuclear energy program in Australia as part of its energy mix.

The ANA recommends repealing the bans in federal legislation on nuclear energy to allow nuclear energy industry to be considered for development in Australia on its merits.

The ANA supports an initial phase of selecting a nuclear power plant design which has been licenced and constructed overseas and assessing the suitability of sites of former or current coal plants in Australia. Several identical reactors should be built at one or more sites.

Dr John Harries

Secretary, Australian Nuclear Association