Australian Academy of Technology & Engineering

Submission to the HOUSE OF REPRESENTATIVES STANDING COMMITTEE ON THE ENVIRONMENT AND ENERGY

INQUIRY INTO PREREQUISITES FOR NUCLEAR ENERGY IN AUSTRALIA

September 2019

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The Australian Academy of Technology and Engineering[1] welcomes the opportunity to respond to the *Inquiry into the Prerequisites for Nuclear Energy in Australia* by the House of Representatives Standing Committee on the Environment and Energy.

Summary

The Australian Academy of Technology and Engineering has proposed for some time that nuclear energy and other aspects of the nuclear fuel cycle should be debated by the Australian community.

Community consent is critical for any successful development. If community concerns about safety can be satisfactorily addressed, as the Academy believes, then nuclear power can be considered as a prospective option to contribute to emissions reduction and reliability of Australia's power system.

Nuclear power is highly capital intensive. While the new generation of small modular reactors (SMRs) has the potential to deliver safely the flexible, dispatchable power required to balance the growing proportion of variable renewable energy in the system, their cost-competitiveness will depend on the successful commercialisation in other markets.

Time and resources will be required to develop the necessary skills and regulatory framework for the safe operation of a nuclear power industry in Australia. Long-term political decision-making, with bipartisan support at both state and federal government levels, is a prerequisite.

It is recommended that priority be given to:

a. Progressing energy market reforms that enable all technologies to contribute to a reliable, low-carbon electricity network at the lowest possible system cost; and

b. Removing existing legislative prohibitions so that nuclear power can be considered on its own merits.

This submission addresses the following Terms of Reference (TOR):

- Health and safety
- Environmental impacts

[1] The Academy is an independent think tank that comprises the leaders in the fields of technology and engineering, who gain Fellowship to the Academy in a highly competitive process. The Academy is one of Australia's four national Learned Academies but uniquely its 800-strong Fellowship come from industry, government and research organisations, as well as academia. Our Fellowship develops trusted, informed and visionary views to persuade decision-makers to implement the most progressive policies on the development of technology for the betterment of Australia and its people. www.atse.org.au

- Energy affordability and reliability
- Community engagement
- Workforce capability

Health and safety

No known energy source is totally free from risk and fossil fuel-based power generation in particular has been linked to serious health consequences. The Academy has long argued for the need to consider both the environmental and health cost externalities of Australia's power generation options[2]. Data presented in the 2006 Uranium Mining, Processing and Nuclear Energy Review (UMPNER) report shows that nuclear power is actually one of the safest non-renewable energy sectors in terms of direct fatalities[3].It also offers significantly low level of greenhouse gas (GHG) emissions.[4]

The safety of nuclear power plants depends on the:

- *Technology chosen*, noting that Generation III large pressurised water reactors and small modular reactors exhibit a step change in safety from early Generation II nuclear power plants
- *Safety of its operation* through adherence to best practice safety analysis and the safety culture of the operating organisation.
- *Effectiveness of the regulatory system*.

No reactor should be considered for Australia that does not meet the highest standards of safety available through the best of the modern designs. In that context, SMRs could be particularly relevant as many designs are based on the principle of inherent safety i.e. they do not require either power or active cooling to ensure safety.

Due to the high capital costs of large power reactors and the need to service small electricity grids (under 4 GWe), there has been a shift towards developing smaller units for nuclear power generation. These smaller units are suitable for remote sites as well, since they have lower requirement for access to cooling water.

Most SMRs are designed for a high level of passive or inherent safety in the event of malfunction. In the *ANS Interim report 2010,* a special committee convened by the American Nuclear Society showed that many safety provisions prudent in large reactors are not necessary in the small designs forthcoming largely due to their higher surface area to volume (and core heat) ratio.

The Academy supports the close and constructive involvement of the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) and the Australian Safeguards and Non-proliferation Office (ASNO) in establishing a long-term regulatory framework for the nuclear fuel cycle in Australia. Given appropriate funding, these organisations have the management and professional skills needed to

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[2] Biegler T 2009, The Hidden Costs of Electricity: Externalities of Power Generation in Australia, The Australian Academy of Technological Sciences and Engineering (ATSE). Available at: https://www.applied.org.au/research-and-policy/publications/publication/the-hidden-costs-of-electricity-externalities-of-power-generation-in-australia/

[3] Commonwealth of Australia 2006, Uranium Mining, Processing and Nuclear Energy — Opportunities for Australia?, Report to the Prime Minister by the Uranium Mining, Processing and Nuclear Energy Review (UMPNER) Taskforce, Table 6.1: Fatal accidents in the worldwide energy sector, 1969–20

[4] Markandya, A. and P. Wilkinson, Electricity generation and health. The Lancet, 2007. 370(9591): p. 979-990. http://www.thelancet.com/article/S0140-6736(07)61253-7/abstract.

develop a robust regulatory framework for Australia, drawing on international experience where relevant.

Environmental impacts

Nuclear power plants offer greater flexibility in location than coal-fired plants due to fuel logistics, giving them more potential for their siting to be determined by cooling considerations.[5] Most importantly, nuclear is a decisively low-carbon technology across the full lifecycle.[6]

Once-through wet cooling using seawater is appropriate for coastal and tidal estuary sites, whereas dry cooling (i.e. radiator cooling) or evaporative cooling (via cooling towers) are also well-proven and effective technologies. Dry cooling techniques may be chosen for SMRs where access to water is more restricted, or environmental considerations are prioritised.The Heller cooling system[7], an engineered hybrid of wet and dry cooling could also offer an attractive solution in some circumstances. The water cooling systems cited (apart from the Heller cooling system) are in current use for Australian coal generation which supplies over 75% of the National Electricity Market (NEM) energy. Thus the longer term deployment of nuclear to replace ageing coal would add negligibly to water demands, especially if the Heller cooling system is deployed.

Sound geophysical conditions such as regions free from earthquake, landslip, flood, excessive storms or other similar risks are also a critical safety and environmental requirement. These risks need to be evaluated in light of the potential increase in severity and frequency of storms due to climate change. Resilience to such conditions is a key consideration in the siting, design and engineering of nuclear power stations. Over 50 years of operation globally they have proved highly resilient to seismic activity, as well as weather extremes. The evidence demonstrates that sufficient robustness can be engineered in to withstand future climactic stresses. The technological capability exists and the challenges lies rather in communication to the public that they could rely on the safety standards that would be built in to any nuclear installation in Australia.

Energy affordability and reliability

Potentially, nuclear power could play a useful role in replacing fossil-fuel thermal in generation energy supply.

A World Nuclear Association 2015 report on SMR standardization of licensing and harmonization of regulatory requirements[8], quoted that the potential of SMRs rests on the following factors:

- Because of their small size and modularity, SMRs could almost be completely built in a controlled factory setting and installed module by module, improving the level of construction quality and efficiency.

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[5] World Nuclear Association, Cooling Power Plants (updated February 2019).Available at: https://www.world-nuclear.org/information-library/current-and-future-generation/cooling-power-plants.aspx

[6] National Renewable Energy Laboratory. *Life Cycle Assessment Harmonization*. 2014 March 7 2016 [cited 2016 7 August]; Available at: https://www.nrel.gov/analysis/life-cycle-assessment.html

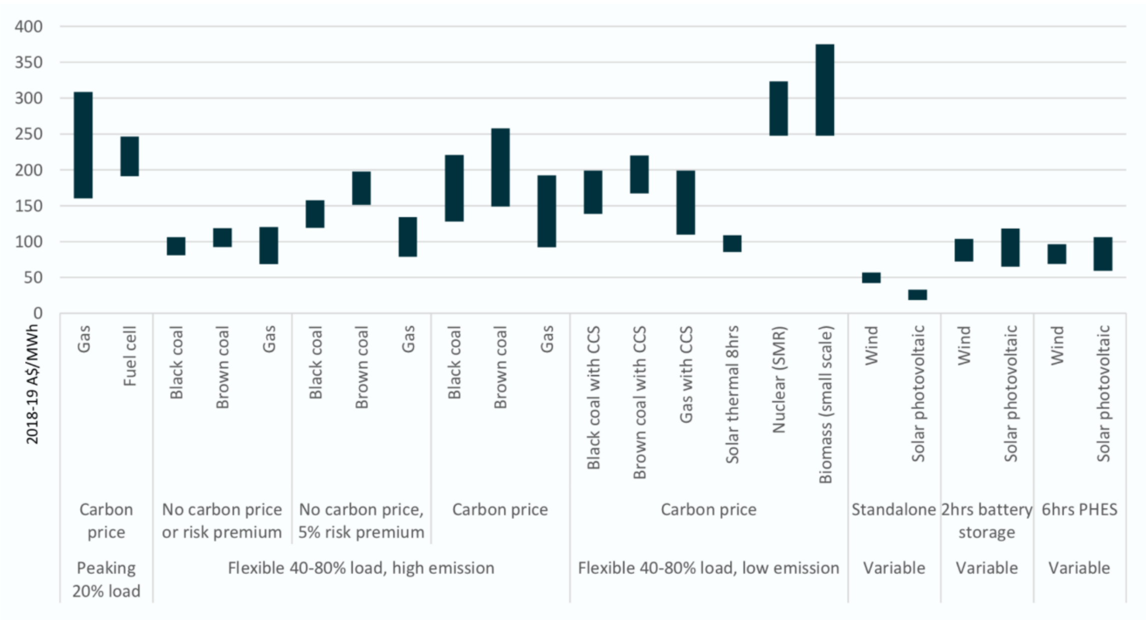
[7] Enexio 2019, Heller Indirect Dry Cooling Systems. Available at: https://www.enexio.com/cooling-solutions/dry-cooling-systems/heller-indirect-dry-cooling-systems/

[8] World-nuclear.org. (2019). [online] Available at: http://world-nuclear.org/uploadedFiles/org/WNA/Publications/Working_Group_Reports/REPORT_Facilitating_Intl_Licensing_of_SMRs.pdf [Accessed 12 Sep. 2019].

- Their small size and passive safety features lend them to countries with smaller grids and less experience of nuclear power.
- Size, construction efficiency and passive safety systems (requiring less redundancy) can lead to easier financing compared to that for larger plants.
- Moreover, achieving 'economies of series production' for a specific SMR design will reduce costs further.

According to the World Nuclear Association, three small reactor designs are currently operational around the world. Fifteen types of small reactor designs are either under construction or at the near-term deployment stage.[9] At this early stage, it is hard to forecast definitively how cost competitive these designs might become.

Analysis presented by the Australian Energy Market Operator (AEMO) and Commonwealth Scientific and Industrial Research Organisation (CSIRO) in the *GenCost 2018* report, projects the levelised cost of electricity (LCOE) for SMRs to be significantly higher in comparison to a broad range of other low- or zero-emission base-load technologies.[10]The study also considers that the projected capital costs for SMRs (from 2018 to 2050) and large scale nuclear reactors (2015 and 2017 projections to 2050) are not likely to fall appreciably in the timeframe from now to 2050.



LCOE projections by technology and category for 2050 (source: *Graham, P.W., Hayward, J, Foster, J., Story, O.1 and Havas, L. 2018, GenCost 2018. CSIRO, Australia*)

By contrast, the 2019 OECD and Nuclear Energy Agency (NEA) Report -*The Costs of Decarbonisation: System Costs with High Shares of Nuclear and Renewables*[11] predicts that further cost reductions for nuclear generation, possibly in the form of SMRs, are likely between now and 2050 as technologies get cheaper and more flexible with ongoing R&D efforts.

[9]World Nuclear Association, Small Nuclear Power Reactors (updated May 2019). Available at: https://www.world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-power-reactors/small-nuclear-power-reactors.aspx

[11] Oecd-nea.org. (2019). [online] Available at: https://www.oecd-nea.org/ndd/pubs/2019/7335-system-costs-es.pdf [Accessed 13 Sep. 2019].

A recent MIT study[12] revealed that the capital cost can account for more than 80% of the cost of energy from a new nuclear plant, with operation and maintenance (O&M) and fuel costs at costs at 15% and 5% respectively.The 2015 OECD study on *Projected Costs of Generating Electricity* showed the sensitivity of LCOE comparisons to discount rates. The range for LCOE varied much more for nuclear than coal with different discount rates. At 3% discount rate, nuclear was substantially cheaper than the alternatives in all countries, comparable with coal and cheaper than Combined Cycle Gas Turbine (CCGT) at 7%, and comparable with both coal and CCGT at 10%. This suggests that nuclear energy is unlikely to deliver sufficient financial returns to attract private investment without government support.

The Academy recognises that these estimates do not take into account the full system costs associated with any particular generation technology: in particular the additional balancing that is required alongside variable renewable generation as its share of the generation mix increases. Reforms to energy market design to value system support capabilities as well as energy could improve the relative economics of nuclear power in some locations.

Community engagement

Australia would require sophisticated planning and consent-based decision making in the development of any nuclear fuel cycle activities. The need to address social concerns is paramount, whilst acknowledging the particular interests and experiences of regional, remote and Aboriginal communities.

Should Australia consider the deployment of nuclear power generation in the near future, it will be necessary to undertake an extensive and openly transparent community engagement process. Meaningful discussions on the benefits and safety of nuclear energy would provide insight into the attitudes of Australians and can thus inform the national consensus on nuclear energy.

An independent study of the related business opportunities and potential job creation arising from Australia's adoption of nuclear power would benefit this engagement process. The Academy also recognises the key role of education and science-based community engagement in enabling a genuine and rational debate about nuclear power in the future energy mix for Australia. A series of core actions on community engagement, including dealing with the media and political community is essential to the development of nuclear energy options.

It is suggested that the Committee consider the experiences of countries such as Finland and Sweden, who have achieved success in this challenging domain.

Workforce capability

Human capital is an important prerequisite for any future development on nuclear energy generation. It is likely to take significant time to build a workforce of local engineers, scientists and regulators specializing in various aspects of the nuclear industry. The long-term nature of the issue highlights the need to ensure the involvement of the younger generation in the engagement process.

Australians returning from overseas nuclear work and international specialists would be able to fill any gaps over time. It is recommended that Australia considers international partnerships in nuclear education, research and development to equip the workforce with the requisite skills.

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[12] Massachusetts Institute of Technology(2018), *The Future of Nuclear Energy in a Carbon-Constrained World.*[Online]available at: https://energy.mit.edu/wp-content/uploads/2018/09/The-Future-of-Nuclear-Energy-in-a-Carbon-Constrained-World.pdf

However, the Academy notes that countries that previously have not had a nuclear industry, such as the UAE, are successfully training a workforce during the period of construction of the nuclear power plants.[13]

Concluding remarks

In an international carbon-constrained policy environment, and with an aging fleet of fossil fuel power stations whose capacity will need to be replaced over the next three decades, nuclear power should not be ruled out as an option for future power supply in Australia. Whether it can compete economically with alternative low-carbon technologies (renewables with storage and a smart grid) remains uncertain. As the International Energy Agency recently commented: "There are still technological uncertainties concerning nuclear new-build cost reductions for Gen III/III+ reactors as designs move from first-of-a-kind to series reactors. The cost-effectiveness of more innovative designs for SMRs and other advanced reactors is also uncertain."[14] Should Australia proceed towards adoption of nuclear power it must do so within the International Atomic Energy Agency (IAEA) full scope safeguards. The management of interim and long-term storage of nuclear waste will also need to be based on established international best practice.[15]

Australia's participation in global nuclear fuel cycles and the maintenance of capabilities that will enable an ongoing contribution to global nuclear safeguards and safety will be important for any potential careful development in this area.

On balance, development of a regulatory framework for nuclear fuel cycle activities without a clear business case would be a challenging exercise, and consume valuable policy and regulatory design resources that might otherwise be dedicated to more pressing challenges in energy policy. However, the Academy recommends that the existing legislative barriers be removed so that nuclear energy can be considered on its own merits.

[13] Iaea.org. (2019). *Nuclear power for a clean-energy future*. [online] Available at: https://www.iaea.org/sites/default/files/publications/magazines/bulletin/bull/bull584-nov2017_corr.pdf [Accessed 10 Sep. 2019]

[14] International Energy Agency, Nuclear power: Tracking Clean Energy Progress (updated May 2019)

[15] Nuclear Energy is an Option, The Australian Academy of Technological Sciences and Engineering. Available at: https://www.applied.org.au/research-and-policy/publications/publication/nuclear-energy-is-an-option/