ENGINEERS AUSTRALIA

CELEBRATING OUR CENTENARY

Defining the option: Nuclear generation in Australia

Submission to the Victorian Legislative Council Standing Committee on the Environment and Planning, Inquiry into Nuclear Prohibition

February 2020

Defining the Option: Nuclear generation in Australia

Engineers Australia
11 National Circuit, Barton ACT 2600

Email: publicaffairs@engineersaustralia.org.au

www.engineersaustralia.org.au

Table of Contents

1. Introduction

Engineers Australia welcomes the opportunity to provide input into the Victorian Legislative Council Standing Committee on the Environment and Planning, Inquiry into Nuclear Prohibition.

Engineers Australia is the peak body of the engineering profession. We are a professional association with about 100,000 individual members. Established in 1919, Engineers Australia is a not-for-profit organisation, constituted by Royal Charter to advance the science and practice of engineering for the benefit of the community.

1.1 Role of engineers and Engineers Australia

Engineers have a critical role in delivering the practical innovations necessary for long term prosperity. At its core, the task of engineers is to create the objects and systems that enable Australians across the economy to live prosperous lives. Engineers do this through innovation and risk management across the value chain.

Transitioning the Australian electricity system to a low carbon state is primarily driven by technology development and deployment. In its simplest terms, coal is losing its dominance in the global energy system, whilst the influence of renewables is increasing. A toolkit approach is required for Australia to address the energy trilemma of cost, reliability and emissions reduction.

The question asked by the inquiry is whether nuclear should be included in this toolkit. Engineers Australia has a strong interest in contributing for two reasons:

- The broad and deep technical capability held by our 100,000 members means we are uniquely positioned to make a strong, expert based contribution to the debate, and
- Our Royal Charter directs us to focus on and work in the community interest.

Engineers Australia is focused on using our expertise to deliver solutions that consider the broader social context.

1.2 Context

There are three broad types of nuclear generation technologies.

- Conventional nuclear generators are part of the energy mix for 31 countries. These are generally large-scale plants that require significant planning underpinned by an existing nuclear industry capability. They are unlikely to be a practical option for Australia.
- Small Modular Reactor (SMR) technology is promoted as the nuclear energy option that is most relevant to the Australian context because of expected improvements in safety, flexibility, scalability and cost-effectiveness. They are not yet commercially available, but this is likely to change over the next 5 to 15 years.
- Gen IV technologies are future reactor designs being actively developed and coordinated through international collaboration.

Engineers Australia has provided a detailed assessment of the technical issues associated with the nuclear fuel cycle in Australia through its submission to the 2015 South Australian Royal Commission on this matter.[1] This provides relevant background including in relation to safety issues. This information is not repeated in this submission.

1.3 Challenge

The key tension at the heart of this inquiry is framed by the following issues:

- SMR technology, if commercially deployed, may be a useful addition to Australia's technology toolkit for electricity generation. It has potential to strengthen the capacity to transition to a low carbon energy system.

[1] Engineers Australia, *Submission to the Nuclear Fuel Cycle Royal Commission*, August 2015

- The current energy system is subject to rapid technological change which is driving fundamental shifts in the economics and technical requirements of electricity generation.
- There are diverse but passionate views about the suitability of nuclear technology for deployment in Australia. These views are underpinned by prohibitions against nuclear industry development at federal and state levels.

The key task of the inquiry is to acknowledge the strength and complexity of these views and challenges while finding practical means to build social licence.

2. Key messages

2.1 Informed debate

This submission is calibrated to address this underpinning challenge of consensus building. Engineers Australia's observation is that there are clear gaps in our collective understanding of how SMR technology might fit and function in an Australian context. These blind spots need to be addressed as the basis for progressing the debate.

Engineers Australia notes:

- *Economics*: The cost competitiveness of SMR technologies is unknown. This is because the technology has not yet been commercially deployed and there is no place for the technology to be systematically monitored and evaluated in the Australian context.
- *Function*: There is no clarity on the likely role, function and scale that SMR technology may have in a future energy market. This encourages speculation about SMRs as: a like-for-like substitute for the expected withdrawal of coal fired generation; or conversely, unnecessary because rapid developments in renewable energy technologies will meet any needs. Neither is a strong basis for assessment of the likely need or contribution of nuclear energy or, for that matter, any technology.
- *Framework*: There is no practical information available about requirements needed to manage SMR technology in Australia. This hampers the ability for open debate about how risk and safety might be managed for SMRs in practice.

In short, these are basic information needs driven by:

- The lack of a track record for SMR technologies
- Uncertainty about the clarity of role/need for SMRs, and
- The absence of a pathway for the safe delivery and operation of SMRs.

Each can be readily informed by targeted work packages. To this end we make the following recommendations:

Recommendation 1: Engineers Australia recommends that, once complete, the Australian Energy Market Operator (AEMO) leverage the 2020 Integrated System Plan to undertake additional sensitivity analysis on alternative generation technologies, including nuclear generation, where reliable specifications (including ramp rates, operating conditions, black start etc.) have been provided. This analysis would seek to identify any economic or security benefits arising from the inclusion of small-scale modular reactors across each of the ISP's five modelling scenarios. This should reflect current uncertainties about cost and commercial readiness of the technology.

Recommendation 2: Engineers Australia recommends that the government nominate a body to monitor and report on international deployments – including learning rate, functional performance, cost and safety – to inform public debate. As part of its work, this body should develop an estimate of required Levelised Cost of Electricity (LCOE) – adjusted for total system cost – for SMR technology to be viable in Australia based on the latest available information.

Delivering such information does not require removal of existing regulatory prohibitions; but it does require that they are not used as an excuse to avoid engagement. This points to the need for a clear (and likely ongoing) assessment of the why, what, where, when and how by the bodies who would be expected to administer, manage or oversee a nuclear electricity generation industry in Australia.

Engineers Australia notes the International Atomic Energy Agency document *Milestones in the Development of a National Infrastructure for Nuclear Power*[2] provides guidance on these issues. Due to Australia's existing involvement in uranium mining and operation of a research reactor, much of the required infrastructure is already in place.

2.2 Timing

The underpinning assertion for the above approach is that Australia should not be rushed into action on SMR nuclear technology. Engineers Australia thinks it is prudent to consider our position early to enable informed action if and/or when the technology becomes commercially feasible. The fundamental task however is to consider the technology on its own merits.

The timeframe for making a technical assessment – and any subsequent planning – of SMR technology deployment in Australia should consider the following prerequisites:

- obtaining a licence for a SMR design approved by a reputable nuclear regulatory authority
- enough international deployments to achieve learning curve efficiencies, and
- the ability to put in place measures to manage the nuclear fuel cycle effectively.

2.3 Climate change action

The above does not change the need for immediate and urgent action to address climate change. Engineers Australia accepts the science on climate change and the need for a proactive response. We note the lack of any emissions intensity scheme or a low emissions target in the electricity-generation sector is a key limitation. Engineers Australia makes the point that even with a well-rounded policy suite in place, practical action is needed to support individuals, communities and industry to respond quickly and efficiently.[3] Nuclear generation cannot be viewed as a substitute for broad and coordinated action.

2.4 Other prerequisites

2.4.1 Power system capability

Engineers Australia holds the view that the electrical system underpinning the National Electricity Market (NEM) needs to be strengthened. System strength underpins and determines how the market functions. As it erodes, we see more blackouts and mandated interventions (reserve trading etc). This in turn creates political sensitivity for governments, disrupts orderly market operation and ultimately deters investment.

The National Electricity Market is driven by price-based dispatch over an electrical system that is a large and complex physical machine. Engineers Australia considers that the current market rules are not optimised to support the effective operation of this machine. This outcome is driven by a complex set of interactions including: the actual market dispatch rules, the progression to centralised controls, the communication latency within those signals and the defeat of local automatic controls.

Ensuring the power system can be maintained in a secure and controllable state is a prerequisite for introducing any new technology, including SMR technologies. The key challenge is to ensure that the market dispatch does not systematically undermine the power system control philosophy. This is a fundamental market design question that

---

[2] International Atomic Energy Agency, *Milestones in the Development of a National Infrastructure for Nuclear Power*, NG-G-3.1, 2007

[3] Engineers Australia, *Practical action to meet the Paris Agreement: Response to the Climate Change Authority Consultation Paper*, August 2019

needs to be front and centre of policy making including the advice being sought by COAG on the *Post 2025 Market Design for the National Electricity Market*.

Recommendation 3: Engineers Australia recommends that effective technical power system design and operation be prioritised in market design to ensure sound investment decision making for new technologies, including nuclear generation.

This matter may appear indirectly linked to the framing of this inquiry, but it goes to the heart of the underpinning challenge: delivering electricity that is affordable, reliable and environmentally responsible requires massive and fundamental change to the operating philosophy of the electrical system. We need to get this right as the basis for rational decision making about future investment choices.

2.4.2 Future industries

We also note that future nuclear technologies (Gen IV) promise to deliver further technology improvements, including in relation to: safety, cost and application (such as process heat and direct hydrogen production). Australia cannot readily influence the timing for international progress other than through existing channels (as noted below). However, we think that there are sensible actions that should be pursued now to position Australia to take advantage of opportunities as they arise. These primarily relate to building the capacity of industry to integrate energy technologies into systems and processes rather than as just as an energy source. Australia, as an active member of the Gen IV International Forum, can accurately assess future developments.

Recommendation 4: Engineers Australia recommends that government actively build the readiness of industry to deploy new energy technologies.

3. Background

3.1 Modelling the role of nuclear in a future grid

As is widely acknowledged the electricity sector is undergoing significant transition. The core challenge is to ensure safe, affordable and reliable power to underpin Australia's productivity both now and in the future. The two key dynamics shaping the equation are rapid technology change and the progressive withdrawal of existing coal-fired generation.

Nuclear generation is often seen as a direct substitution for the services provided by coal fired generators.[4] As the following graph shows, coal fired power station closures are expected to bite by 2035 (based on technical end of life). At this stage it is not clear how the balancing and security services provided by the electrical system in its current configuration can be maintained (or achieved otherwise).

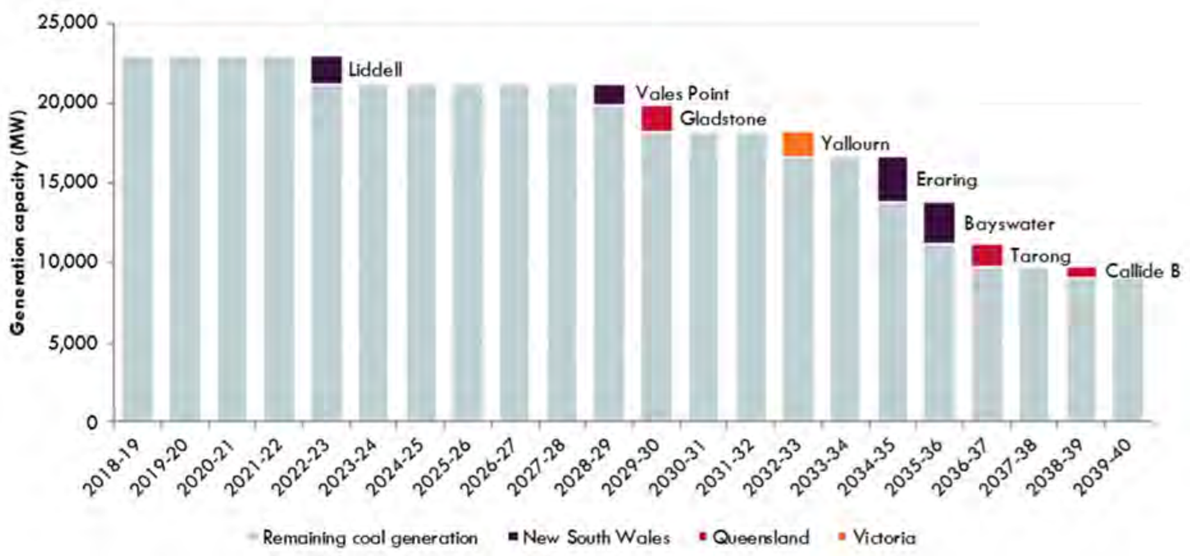

Figure 1: NEM coal-fired generation fleet operating life to 2040, by 50th year from full operation or announced retirement[5]

Engineers Australia sees little value in thinking in terms of like-for-like substitutions. We instead need to understand how the electricity market and power system will function at the point that nuclear technologies may be commercially feasible for deployment in Australia. The following graph illustrates the quickening pace and scale of technology shifts in generation in the NEM (along with its volatility).

[4] Engineers Australia, *The retirement of coal fired power stations: Engineers Australia submission to the Senate Standing Committee for Environment and Communications inquiry*, 2016
[5] Australian Energy Market Operator, *Integrated System Plan for the National Electricity Market*, July 2018, p.22

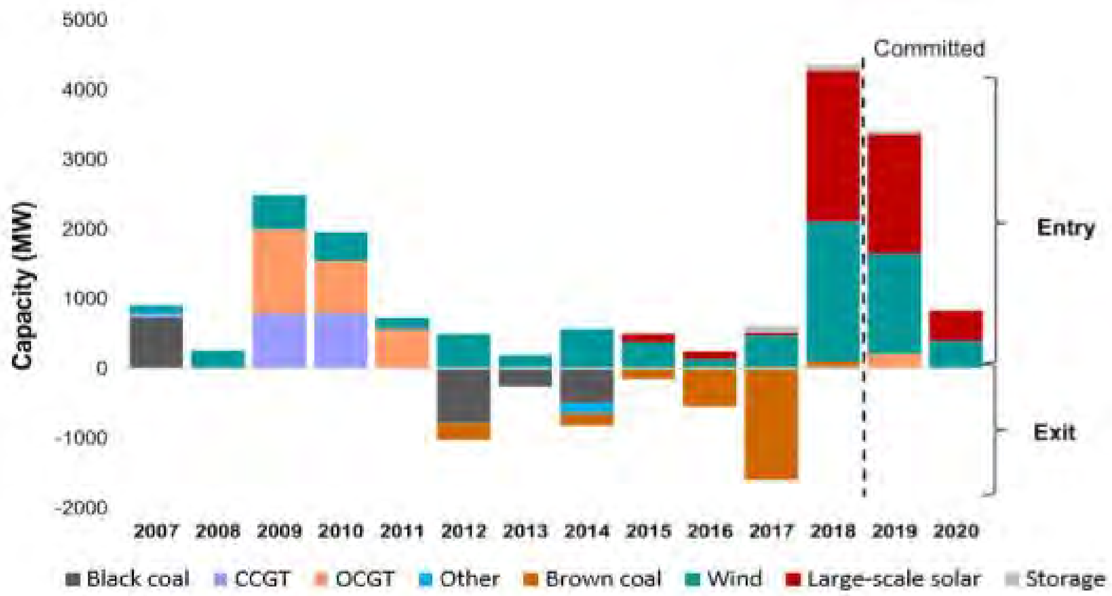

Figure 2: Entry and exit of generation capacity in the National Electricity Market by technology[6]

Future context is critically important for framing what contribution nuclear power could or should make. This includes understanding what we will need from the technology if it was made available in a system that has successfully integrated more storage, more distributed generation and more rooftop solar. The considerations include specificity like how many SMR installations, at what size, in which locations and providing which services.

This is a core issue for assessing economic feasibility and is a point reinforced by the Nuclear Fuel Cycle Royal Commission (South Australia). It noted that: "The future viability of nuclear power, as for any generation source, can only be analysed as part of the electricity supply system in which it would be integrated".[7]

Based on the information to hand we cannot assess what functional role, if any, that nuclear will be able to serve competitively. This reflects that SMR is an emerging technology and therefore it is hard to assess the associated costs. More pertinently, possible SMR technology deployment has not been modelled at a national level.

The Australian Energy Market Operator (AEMO) Integrated System Plan (ISP) is a ready-made platform for providing a forward-looking assessment of the context for nuclear deployment. It is a modelling tool with a focus on meeting the long-term needs of the electricity system as a whole in accordance with the National Electricity Objective (of the National Electricity Law). It does not consider nuclear technologies because they are not a credible option in the current environment (i.e. they are prohibited). Nonetheless, the ISP could be used to better articulate the role of alternative technologies to provide a view on the likely scope and investment horizon for nuclear power in the Australian context.

3.2 Cost and commercial readiness

There is no price certainty for SMRs because the technology has not yet been deployed and consequently has no performance track record. NuScale is expected to be the first company to achieve design certification (at current estimates, in 2020).[8] The learning curve for SMR technology is expected to be greatly assisted by the availability of lessons learnt from conventional nuclear reactor design, construction and deployment. Accordingly, the general

[6] COAG Energy Council, *Energy Security Board Post 2025 Market Design – Issues Paper*, September 2019, p.13

[7] Nuclear Fuel Cycle Royal Commission, Government of South Australia, *Nuclear Fuel Cycle Royal Commission Report*, 2016, p.47.

[8] The Nuclear Energy Agency forecasts in its high-case scenario, that up to 21 GWe of SMRs could be added globally by 2035, representing approximately 3% of total installed nuclear capacity. Nuclear Energy Agency, *Small Modular Reactors: Nuclear Energy Market Potential for Near-term Deployment*, 2016

expectation is that SMR capital costs are likely to be lower than conventional nuclear installations. However, as with all technology deployment efforts there are significant risks attached to successful commercialisation.

The spread of projected and reported capital costs is unsurprisingly broad. In Australia the most recent public assessment is provided by the GenCost2018 report by CSIRO and AEMO.[9] It assumes the capital costs for SMR technology is $16,000/kW in 2020 (and experiences no major price decline over time). We note this number is more than double other cost estimates worldwide. We have sought additional clarification on the basis for this costing. Initial advice is that the number is based on a GHD estimate for AEMO of costs for a future Gen IV reactor to be constructed in 2035 and not for the type of reactor which would most likely be deployed in Australia.

3.2.1 Target price

Engineers Australia's view is that no source can provide an accurate predictive cost estimate until the technology is successful deployed. Nonetheless, it may be possible to set a benchmark indirectly by estimating the bidding profile required of a SMR for it to be competitively dispatched into the grid. In the absence of agreed cost values this is a logical basis on which to conduct the sensitivity analysis recommended above (Recommendation 1).

3.2.2 Characterising supply chain requirements for deployment and safety

Breaking down the levelised cost of electricity (LCOE) will involve assessing inputs such as workforce needs, supply chain development and safety requirements. Doing so will provide the basis for an assessment of Australia's capability needs for the direct deployment of SMRs.

SMR technology deployment may be able to make significant use of existing skills and manufacturing infrastructure. Australia's OPAL reactor, for example, was built by a consortium led by John Holland which has a strong track record in civil projects. The modular nature of SMRs may enable a high level of Australian content but determining how much requires detailed assessment. This is an area that requires further examination.

Likewise, Australia has an existing nuclear regulator. We do not know with certainty the level of resourcing needed for oversight of a nuclear generation sector. A comprehensive LCOE assessment could take this into account to provide an indicative basis for debate.

3.2.3 Learning curve

If Australia did choose to introduce SMR technology, Engineers Australia's view is that Australia should not be a first mover. There is significant risk attached to first-of-a-kind deployment and there is an associated learning curve experienced in the subsequent installations. Delaying adoption would provide the necessary breathing room to monitor costs and technology deployment success objectively. A conservative approach is also warranted given the status of community acceptance for nuclear technologies in Australia.

3.3 Market design challenges

Engineers Australia observes that much of the debate about the need for nuclear generation is driven by the view that the grid is becoming increasingly unstable. We agree that system strength has declined over time. However, our view is that the root cause is the current regulatory regime which prioritises commercially oriented rule making over high quality power system design and management of power dynamics. We think that this situation needs to be systematically remedied to ensure Australia can confidently introduce new technologies into the generation mix. Without this, we are concerned that investment signals for technologies such as nuclear will continue to be obscured by 'noise' created by suboptimal market settings.

Engineers Australia continues to engage on these issues. However, for the purpose of this inquiry we highlight the following actions as key enablers of new technology into the market (and supporting Recommendation 4 above).

[9] Graham, P., Hayward, J., Foster, J., Story, O., and Havas, L. *GenCost2018: Updated Projections of Electricity Generation Costs*, December 2018

- Technology integration: supporting engineers (in AEMO etc) to find integration solutions that allow orderly entry, operation and exit of generation across technology types. This includes early exposure and engagement with proposed technology solutions.
- Transmission planning: drive whole of system transmission planning building on AEMO's Integrated System Plan.
- Power dynamics: ensuring that essential security services[10] are planned and delivered effectively, by for example, ensuring generators are properly incentivised to more actively manage frequency.

3.4 Long term prosperity

In the longer term, Gen IV technologies promise to increase the cost efficiency and range of services provided through nuclear generation, including: industrial process heat, generating hydrogen for export, and water desalination. Assuming safety and community concerns can be addressed effectively, it is easy to see how each could transform and expand Australia's economic opportunities and reduce emissions in other sectors in addition to electricity generation.

Australia currently plays an active role in developing these options through its membership to the Generation IV International Forum. Gen IV technologies are, however, not generally expected to be demonstrated or commercially available until at least 2030-2040. This is a long timeframe reflecting the scale of research and development required to commercialise innovative designs. However, China is commissioning the world's first commercial size Gen IV Very High Temperature Gas Reactor so the pace of development could increase.

While we can do little to accelerate technology readiness domestically, we can position Australia to be ready to capitalise on these opportunities. There are sensible actions that can be taken now to build supply chains, workforce skills and technical know-how in Australian industry. They are largely the same actions that are required for success in contemporary efforts to integrate renewable energy into existing production systems. This is because the technology itself, while critical, is an enabler and input to supply chain development.

This is made clear by the Hydrogen Strategy Group in its report to the COAG Energy Council.[11] It notes that price declines for solar Photovoltaics (PV) is one of the enablers for hydrogen exports. However, it also concludes that addressing supply chain issues – such as transport infrastructure and regulatory requirements for international shipping – are just as essential for converting this potential into commercial reality.

A systems-based approach is necessary to support the use cases for SMR and Gen IV technologies. For example:

- Mining: There has been limited uptake of renewable energy integration projects on mining critical loads despite a strong economic business case. This does not solely reflect technology limitations. It is also due to the difficulty companies face in assessing and managing new technology performance and integration risks. This is the conclusion reached in a recent review of the Australian Renewable Energy Agency (ARENA) Regional Australia's Renewables Program. It found that "the structural barriers of governance, supply chains, and finance" are key impediments to broad uptake and "need to be tackled further to lower soft costs".[12]
- Process heat: Industry is the largest user of energy in Australia, and around two thirds of that energy is used to produce heat for industrial and other processes[13]. Most of this heat is generated from gas. Transitioning to alternative technologies is an opportunity for carbon and cost savings. Advanced nuclear can directly supply process heat. However, doing so generally requires a highly robust understanding of the energy mass balance in production processes. The need to build the capacity for technical decision making is as true for nuclear as renewables.

---

[10] "Essential security services are synchronous inertia, system strength and voltage control".
Commonwealth of Australia, *Independent Review into the Future Security of the National Electricity Market - Blueprint for the Future*, June 2017, p.51

[11] Commonwealth of Australia, *Hydrogen for Australia's Future*, 2018

[12] Herteleer, B., Dobb, A., Boyd, O., Rodgers, S., Frearson, L., *Identifying risks, costs, and lessons from ARENA-funded off-grid renewable energy projects in regional Australia*, Progress in Pholtovoltaics, v.26, issue. 8, pp. 642-650

[13] Australian Renewable Energy Agency, https://arena.gov.au/renewable-energy/renewables-for-industry/ accessed, 12 September 2019

ENGINEERS
AUSTRALIA

100
CELEBRATING
OUR CENTENARY