The Transformation of Australia's Power System:

A Submission by SMR Nuclear Technology to the Review of the Security of the Australian National Electricity Market

February, 2017

Executive Summary

Australia has a serious problem:

- *We must preserve the security and affordability of our electricity supply.*
- *At the same time, we need to reduce our greenhouse gas emissions as fast as we can afford to do so.*
- *Australia's plans must take full advantage of all new technology developments, including nuclear, but cannot do so whilst the legislative ban on nuclear remains.*
- *Successive governments have endorsed a "Technology Neutral" policy but have not taken the necessary actions for this to be enabled.*

And a serious solution: SMR technology

- *Australia must have access to all low-emissions electricity generation technologies, particularly those that are not weather-dependent and provide system stability.*
- *Within 15 years from Australia lifting its nuclear ban, small modular reactors can make the most decisive contribution to the transformation of Australia's power system, at a total system price competitive with wind energy.*

1. Introduction: Small Modular Reactors (SMRs) are the modern alternative to large, centralised power stations and have the potential to transform Australia's power system within 15 years

Over the next decade and beyond, many fossil fuel plants in Australia will reach the end of their commercial lives and will need replacing. Many are already struggling to remain viable with increasing costs of refurbishment and life extension, and increased competition for dispatch against subsidised renewables.

Large, centralised power stations, nuclear or otherwise, may never again be needed in Australia.

SMRs represent the next wave of innovation in sustainable power systems. SMRs not only provide reliable base-load power but they decentralise power sources and are perfectly suited for Australia's future needs.

Modern SMRs also have the ability to 'load follow' and are complementary to renewable sources of power. SMRs are the perfect adjunct to the power system.

Modern SMRs are also very safe. SMRs have been used to safely power submarines for 60 years. They are now being developed in land-based mode in Argentina, China, Korea, Russia and the United States.

Within 15 years, strategically located SMRs, developed in lines of up to 12 x 50MW units, could transform Australia's power system by reducing greenhouse gas emissions from power generation and enhancing the security of the entire power system. This could not however occur unless Australia amends its legislation to allow SMRs to be developed.

The 2016 South Australia Nuclear Fuel Cycle Royal Commission (NFCRC) estimated that a nuclear power plant could be operating by 2030. We consider a planned 2030 commercial operating date for such a facility in Australia is achievable for an SMR.

2. Over 30 countries presently utilise nuclear power

Australia is the only country in the OECD to have banned nuclear power.

Worldwide, over 30 countries presently utilise nuclear power, typically using large, centralised, nuclear power stations because they have provided economies of scale. There are 447 nuclear power generation reactors in operation globally, plus 60 under construction and 164 in planning.

Globally, nuclear power generates around 11% of total electricity.

Australia has one of the world's highest electricity generation emissions intensities, typically 850 kgCO2/MWh. This is attributable to our high dependence on fossil fuels. Many countries have achieved emissions intensities of one-third of Australia's. The majority of these countries achieving much lower emission intensities than Australia have nuclear in their energy mix, among these being. Sweden, France, Finland, Belgium, Switzerland, Spain and Canada. Only countries with extensive hydro resources, e.g. Norway, or geothermal resources, for example Iceland, have achieved low emissions without nuclear.

Major fossil fuel exporting nations, such as Saudi Arabia and the UAE, are now developing nuclear industries as part of their energy security strategies.

The US DOE is supporting the design development, and licensing of SMR Nuclear power plants. NuScale (USA) is on track to have their first SMR operating by 2024. Their client is Utah Associated Municipal Power Systems (UAMPS), a power cooperative that is developing an SMR on the US Department of Energy's Idaho National Laboratory site. NuScale submitted its Design Certification Application to the US Nuclear Regulatory Commission on 12 January 2017.

3. SMRs have high natural safety

SMRs have high natural safety. No external electrical supplies or pumps or manual intervention are required for emergency cooling, enabling them to remain safe under extreme conditions.

SMRs are air-cooled and do not need to be sited in coastal locations for turbine condenser cooling water.

SMRs can be installed underground, further enhancing their security against accidents or external events.

4. SMRs are competitive and affordable

SMRs provide a competitive whole-of-life levelised cost of generation against other technology options. Factors contributing to this are:

- Much lower long-term forward fuel prices and less likelihood of supply/demand volatility
- Greater redundancy for outage cover as a result of the much smaller unit capacity, for example the 50 MW NuScale (USA) SMR, and hence reduced reserve capacity required to cover peak firm capability required for any development.
- Greatly flexibility in scale of any individual SMR nuclear power station installation - making possible smaller 3-unit (150MW), to 6-unit (300MW), or larger power station developments, to suit locations, and to spread new generation requirements around different locations of a grid, more closely matching the different regional load growth requirements.
- Further major transmission savings - possible as a result of the smaller power station scales, down for example to 3-unit (150MW) power stations, at the extremities of existing power networks in decentralised locations.
- Greater capital cost certainty - as a result of a larger factory-built component of cost and lower site construction costs.
- Capacity factor in excess of 95%
- Long operational life.
- Extended refuelling cycles; and
- Simple operating systems requiring less maintenance.

SMRs are less capital-intensive than the large-scale, traditional plants and are faster to build. Additional modules may be installed in an incremental fashion when extra capacity is required. Plants can in this respect be “self-financing” with the generation profits from early modules paying for the cost of additional modules.

5. SMRs will bring other benefits to the power systems

The characteristics of electricity supply and demand require a combination of technologies. The benefits of SMRs include:

i. SMRs reduce the burden on the transmission grid;

ii. SMRs are especially suited for remote locations, such as for towns and mining and industrial projects at the extremities of the transmission system, where the transport of fuel for conventional generating plant is expensive.

iii. SMRs can be multipurpose facilities - producing not only electricity but also heat for industrial processes and desalination.

iv. SMRs can also produce high-temperature industrial heat for oil shale and oil sands processing, coal gasification and high-temperature steam electrolysis.

6. Nuclear power is unnecessarily prohibited in Australia: it needs a line of sight to compete with other technologies

The Australian legislative prohibition is explained in part by Australia’s abundance of other energy resources and in part by historical safety concerns overseas. At the time when the Australian prohibition was put in place, there was little community appreciation of the benefits of low-emissions technologies.

The rationale for the Australian legislative prohibition has been diminished by the 1994 IAEA Convention on Nuclear Safety (CNS), to which Australia became a party in 1996. The CNS laid down nuclear safety principles which all member states must strictly enforce and report on.

SMRs must be built to the latest safety standards, installed in safe locations, operated in accordance with best international practice and regulated by a professional regulatory agency. This is the case with the OPAL research reactor that has been operated by ANSTO at Lucas Heights since 2006.

7. Nuclear power once had bipartisan support and there is every reason to have it again

In 2006, after an 18-month study, a multi-party Australian Parliamentary Inquiry produced an 800-page report on the strategic importance of Australia's uranium resources for the development of the non-fossil fuel energy industry in Australia (“the Prosser Report”).[1] The report emphasised Australia's need for “*a mix of low-*

[1] *“Australia’s Uranium – Greenhouse Friendly Fuel for an Energy Hungry World: A Case Study into the Strategic Importance of Australia’s Uranium Resources for the Inquiry into Developing Australia’s Non-Fossil Fuel Energy Industry”,* House of Representatives, Standing Committee on Industry and Resources, Parliament of Commonwealth of Australia, November 2006.

emission energy sources and technologies, including nuclear power." The report's findings were bipartisan and unanimous.

Also in 2006, a report for former Prime Minister Howard ("the UMPNER Report") found that nuclear power was the least-cost low-emission technology that could provide base-load power and play a role in the future generation mix.

The 2016 SA NFCRC report identified that the smaller capacity of SMRs makes them attractive for integration into smaller electricity markets such as the NEM.

8. Community consultation and timing of system transformation

Preparatory work is expensive and cannot be undertaken whilst a legislative ban remains in place.

Preparatory work on particular sites also cannot commence without proper community consultation. It would be reasonable to allow two years for this to be carried out after the legislative ban is removed.

Another four years may be required for site selection, system design, plant scoping and selection, preliminary engineering and technical studies, the obtaining of all planning, environmental and regulatory approvals and carrying out of feasibility studies. During this entire period, community consultation should be continued.

The success of community consultation would culminate with a contract with a selected plant supplier for manufacture and delivery of the first SMR. Detailed engineering, plant procurement, construction of civil works and commissioning of the first plant would then require another two years. Operational commencement of the first SMR plant should be achievable by 2030.

A successful transformation of Australia's power system through the installation of SMRs is estimated as 15 years. This is not long for a sustainable, affordable solution to the low-emissions, energy security challenge that is now facing Australia.

9. Economic opportunities

SMR design, development, installation and operation would provide skilled employment opportunities and jobs in a new field in Australia with long-term growth prospects.

Australia's commercial, technological and regulatory success in this field could also provide export opportunities.

Australia could become a model for other countries that need to transform their own power systems.

Appendix A

Case Study Olympic Dam

Olympic Dam is a very large multi-ore underground mine in South Australia, 550 km NNW of Adelaide. Opened in 1988 and owned since 2005 by BHP Billiton, it is the world's 4th largest copper mine and the world's largest uranium deposit being mined.

Olympic Dam is a remote site, connected to the South Australia electricity grid system by a 275 kV line from Davenport, Port Augusta (270 km long) and also a 132 kV line from Pimba which is used for standby purposes. The site has limited standby diesel capacity. Demand with current operations is 125 -165 MW. BHP Billiton has looked at an expansion of mining at Olympic Dam which would ultimately require about 650 MW (Olympic Dam Expansion EIS). One option would be a CCGT power station on site, but this would require a 400km pipeline.

Following the electricity supply problems in South Australia, and particularly the September 2016 state blackout when Olympic Dam lost two weeks production, escalating electricity costs and the security and reliability of power are significant concerns for BHP Billiton for the sustainability of Olympic Dam.

One option would be to construct a nuclear power plant at Olympic Dam using Small Modular Reactors (SMRs). Olympic Dam is particularly suitable for nuclear power as the site is used to dealing with radiation and radioactive materials. Initially, sufficient 50 MW modules could be installed to supply current operations with further modules being added for a site expansion. The NuScale 50 MW SMR standard plant can have up to 12 modules, maximum 600 MW, requiring only 18 hectares of land and the turbine condensers can be air cooled on a remote site. A suitable initial plant would be 6 modules providing 300 MWe gross.

The NuScale SMR reactor is located underground and the modules sit in a large water pool ensuring that heat can always be removed by natural circulation, without the need for external electricity or water supplies or operator intervention.

Cost of a NuScale nuclear power plant

NuScale and Fluor have carried out a detailed cost estimate of the 600 MW NuScale 12 module plant based on a site in the USA.

For a First of a Kind (FOAK) plant, the overall EPC overnight plant cost is US$2,895 million ($5,078/kW). This is estimated to reduce to $4,300/kW for successive power plants reducing the overnight cost to $2,450m.

Total operating cost, including fuel and used fuel management, is $37/MWh.

Respectfully submitted.

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