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*A Submission by **SMR Nuclear Technology Pty Ltd** to*

The House of Representatives Standing Committee on the Environment and Energy Inquiry into the Prerequisites for Nuclear Energy in Australia

This submission includes two Appendices addressing Scale and SMR Cost Estimates. It replaces an earlier submission dated August 2019

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EXECUTIVE SUMMARY

Nuclear power is already making a vital contribution to reliable, affordable and low-emissions power systems in 31 other countries.

Australia's power system must be reliable, affordable and sustainable. Whilst maintaining high reliability, Australia has to successfully make the transition of its power system to a more affordable system with lower emissions.

In the long run, there may be only four practical technologies available for low-emissions power systems: hydro, solar PV, wind and nuclear power.

Nuclear power is the only one of these that is not weather-dependent.

Nuclear power has high reliability and generates close-to-zero emissions. The high capital cost of traditional large-scale reactors may make them unfeasible in Australia but the advent of Small Modular Reactors (SMRs) with their lower capital cost and an operating life of up to 80 years is likely to make them a game-changer in Australia.

SMRs that would be very suitable for Australia are at an advanced stage of development in several countries. They are designed to be inherently safe. One of the most advanced designs is that of NuScale Power of the US (referred to as NuScale throughout this submission). www.nuscalepower.com

Australia has over 60 years' experience in operating research reactors. A nuclear reactor currently operating in Australia is the 20 MWTh OPAL multi-purpose reactor (for research and manufacture of medical products) operated by the Australian

Nuclear Science and Technology Organisation (ANSTO) at Lucas Heights, Sydney www.ansto.gov.au

Modern SMRs could be the lowest cost generation available in Australia because of their contribution to power system reliability.

Power industry infrastructure, particularly involving nuclear power, is more valuable to the economy than other forms of infrastructure, such as transport, because it provides energy security, generates a return on investment and provides both short and long-term flow-on effects in regional development, not the least being employment opportunities.

Nuclear power generates ionising radiation, exposure to which is harmful to human health. This explains why nuclear safety is non-negotiable and requires strong regulation by a specialist regulatory agency. In Australia's case, this is provided by the Australian Radiation and Nuclear Protection Agency (ARPANSA), a world-class regulator established under Commonwealth law www.arpansa.org.au. ARPANSA leads the development of industry codes and best practice in Australia.

The operation of nuclear power plants for power generation does not enable the use of nuclear weapons nor does it in any way condone or facilitate the proliferation of nuclear weapons in the world. Australia signed the *Treaty on the Non-Proliferation of Nuclear Weapons (NPT)* in 1970.

Important Introductory Statement on Nuclear Safety

SMR Nuclear Technology considers that nuclear safety is paramount and non-negotiable. We endorse the strong regulatory controls provided by the Australian Radiation and Nuclear Protection Agency (ARPANSA), a world-class regulator established under Commonwealth law.

Globally, two organisations provide guidance over the civil nuclear industry in member countries. These are the International Atomic Energy Agency (IAEA) in Vienna, established in 1957, and the Nuclear Energy Agency (NEA) of the Organisation for Economic Cooperation and Development (OECD) in Paris, established in 1958.

The IAEA and the NEA are co-organising the 2019 International Conference on Climate Change and the Role of Nuclear Power, to take place in Vienna from 7 to 11 October 2019. Australia was one of the first countries to sign and ratify the 1970 *Treaty on the Non-Proliferation of Nuclear Weapons (NPT)* confirming Australia's position as a nation that will not acquire nuclear weapons. In addition to the safeguards agreement required by the NPT, in 1997 Australia was the first country to sign the *IAEA Safeguards Additional Protocol* giving inspectors rights of access to any site. 129 countries have followed Australia's lead and signed this protocol.

Prevention of the proliferation of nuclear and chemical weaons is separately provided for by the Australian Security and Non-Proliferation Office (ASNO) within the Department of Foreign Affairs. ASNO's work relates directly to international and national security. ASNO performs domestic regulatory functions to ensure that Australia is in compliance with its treaty commitments and that the public is protected through the application of high standards of safeguards and physical protection to nuclear materials and facilities.

Following the accident at the Chernobyl nuclear power plant in the Ukraine in 1986, the nuclear power industry became what we believe, from a safety point of view, to be the most highly regulated industry in the world.

In 1994, the Convention on Nuclear Safety (CNS) came into force, laying down the fundamental principles for the protection of individuals, society and the environment from the harmful effects of ionising radiation.

The CNS has 152 Member States, including Australia. Under the CNS, each country must establish safety regulations for nuclear power.

This submission now addresses each of the topics in the Inquiry's Terms of Reference in the same order as they are listed there.

Topic A Waste Management, Transport and Storage

Waste Management

Low Level Waste (LLW)

Routine day-to-day operations of a nuclear power plant produce only LLW.

Typical LLW comprises paper, cleaning materials, resins, filters and lightly contaminated scrap metal. LLW is sorted, and compacted into 220 litre drums and stored on site. No shielding is required as the radiation level on the outside of the drum is low. The drum provides containment. Radionuclides with half-lives of less than about thirty years are considered to be short lived. The time for LLW to decay to background levels is normally assumed to be within 300 years.

A 720 MW 12 module NuScale SMR would produce each year 120m^3 (two shipping containers) of LLW that is packaged and stored in drums before being transported to a Low Level Waste repository.

The IAEA guidance for this waste is in a Near Surface Repository. This has engineered features to contain the waste for 300 years, i.e. a number of barriers to restrict release of the radionuclides to the environment.

Intermediate Level Waste (ILW)

An SMR would produce a very small amount, ~1.5m^3/yr of ILW. This is mainly metallic waste from maintenance or refuelling operations. It is stored in a shielded cask.

High Level Waste (HLW)

HLW has higher activity than ILW and produces significant heat. The normally accepted definition of the heat load is > 2kW/m^3.

HLW is not produced during routine day to day reactor operations and is only associated with used fuel.

When a power reactor is refuelled, the used fuel that is removed is highly radioactive and still producing heat. Normal practice is to store the used fuel in a cooling pond close to the reactor for several years to allow the radioactivity and heat load to decay. There are then four options for used fuel management:

- interim dry storage;
- reprocessing if unburnt fissile materials are to be recycled and/or transuranic waste materials are to be removed;
- burning of recycled materials and transuranic waste in a fast neutron reactor;
- final disposal of complete spent fuel assemblies or other HLW in underground storage facilities in geologically stable locations

A NuScale module would produce ~1500kg/year of used fuel (6 fuel assemblies) which is initially stored in cooling ponds and then stored in dry casks on site for the life of the plant. Alternatively, the used fuel could be sent abroad for reprocessing as is the current practice for used fuel from ANSTO's research reactors. The final disposal of the small amount of waste from reprocessing or complete used fuel assemblies will be in a deep geological repository. Construction of this type of facility is in progress in Finland and about to commence in Sweden and France.

Transport

There is very good international agreement and standards for the transport of radioactive materials, because the whole of the nuclear fuel cycle, from ore to waste, involves transport, in many cases between countries.

The IAEA Safety Standard TS-R-1 provides the detailed safety standards and guidance. For Australia, ARPANSA has issued the *Code for the Safe Transport of Radioactive Materials*[1] based on the IAEA Specific Safety Requirements SSR-6 Rev 1 2018. Compliance with this code is mandatory.

[1] Code for the Safe Transport of Radioactive Material RPS C-2 (rev 1) March 2019

Safe transport is ensured by:

- Containment of radioactive materials
- Control of external radiation levels
- Prevention of criticality (limiting the quantity of materials to prevent a nuclear reaction)
- Packages designed to withstand a fire.

Prerequisites for a nuclear power program:

- Waste management: The *Australian Radioactive Waste Management Framework* must be shown to effectively manage radioactive waste
- The legislation and competent authorities are already established in Australia for transport of nuclear materials and there are no new prerequisites

Topic B Health and Safety

Nuclear energy has the lowest incidence of death and accidents amongst all energy production technologies, comparable to renewables. It is many times lower than fossil fuels.

In 2013, the UK Tyndall Centre for Climate Change, in a report for Friends of the Earth, found that:

> *"… overall the safety risks associated with nuclear power appear to be more in line with lifecycle impacts from renewable energy technologies and significantly lower than for coal and natural gas per MWh of supplied energy".*

In 2016, the South Australia Nuclear Fuel Cycle Royal Commission conducted an in-depth inquiry that concluded that safety was not a basis for ruling out nuclear power in Australia.

Modern SMRs are designed to be inherently safe, avoiding Chernobyl-type or Fukushima-type accidents.

SMRs can be installed below ground level. This protects them from external hazards and unauthorised access. The reactor building is able to withstand aircraft impact.

The NuScale module sits in a large "swimming pool" enabling the reactor to be cooled indefinitely without attention.

Modern SMR designs have now become a game-changer for nuclear safety. Although traditional reactors are safe, SMRs take safety to a new level of "walk-away safety". For example, the NuScale SMR does not require any operator action, backup electrical supplies or water supplies and would have survived even the Fukushima accident. The passive safety systems enable the reactor to be cooled indefinitely without attention - "indefinite cooling time".

The US Nuclear Regulatory Commission (NRC) has confirmed that the NuScale plant does not require any emergency electrical generators to keep the plant safe. The NuScale SMR is the first nuclear reactor design to have achieved this accreditation.

The turbine condensers for modern SMRs can be air cooled and do not require large quantities of water. They do not need to be located near a river or on the coast.

Australia's world-class nuclear regulator, ARPANSA, already provides for community participation in its regulatory functions. However, in fashion with the US, the UK and Canada, higher-level participation at board level may nonetheless be appreciated by the general public in Australia.

Nuclear Liability

Potential cross border consequences of a nuclear accident require an international nuclear liability regime, so national laws are supplemented by international conventions.
Australia is not a party to an international nuclear liability convention. Australia's nuclear facilities are covered by an unlimited Commonwealth Government provision.
The latest international convention, designed to modernise and enhance the legal regime, is the *Convention on Supplementary Compensation for Nuclear Damage* which came into force in April 2015. Australia has signed (1997) but not ratified this convention. Prior to the start of a nuclear power program, Australia should consider appropriate nuclear liability arrangements

Prerequisites for a nuclear power program:

- Availability of a suitable reactor which has been licensed in a country with a respected nuclear regulator (e.g. US design licensed by the NRC)
- Increase ARPANSA's resources to provide for increased work flow
- Consideration of the appropriate Nuclear Liability arrangements

Topic C Environmental Impacts

i) Emissions

Energy production not only has short-term health impacts relating to accidents and air pollution; there are also the long-term, environmental impacts relating to climate change. Signs of this are already starting to show, with extreme weather events, reduced rainfall, sea level rise, etc.

Australia must utilise every safe, low-emissions technology to reduce its emissions. Nuclear is a safe, low-emissions technology that should be included in the energy mix in Australia, as it is already in 31 other countries, with four new countries with nuclear power reactors presently under construction.

Nuclear power, like wind and solar, has zero operating emissions. The South Australia Nuclear Fuel Cycle Royal Commission examined in detail the whole of life cycle emissions for different electricity generation technologies. The median value for nuclear is 12kg/MWh, the same as wind. Solar is slightly higher at 18-50 kg/MWh.

The Finkel Review reported a very large difference between low-emissions technologies (wind, solar, hydro, nuclear) that have zero operating emissions and the lowest intensity fossil technology, CCGT, that has an operating emissions intensity of 370 kg/MWh.

In 2018, 2,563 TWh was generated by nuclear power reactors worldwide, saving over 2 billion tonnes CO2-e emissions (World Nuclear Association). Also in 2018, nuclear generated more electricity than solar and wind combined.

In 2015/16, Australia exported 8,417 tonnes of uranium oxide concentrate (ASNO Annual Report) which would have generated ~280 TWh and saved the recipient countries more than 250 million tonnes CO2-e, yet Australia does not take advantage of this valuable resource.

ii) Contribution of Nuclear to National Emissions Target

Australia’s annual emissions from electricity generation for the year December 2012 were 191 million tonnes CO2-e (National Greenhouse Gas Inventory).

Five years later, and after billions of dollars spent on wind and solar, Australia’s annual emissions from electricity generation for the year March 2017 were 188 million tonnes CO2-e.

Australia has one of the world’s highest emission intensities, typically 820 kg CO2-e /MWh (Finkel Review). Countries with low emissions intensities either have large hydro resources (Norway) or have nuclear as part of their energy mix (France, Belgium).

We emphasise that no country has achieved a low level of emissions without extensive investment in nuclear energy and/or hydro.

iii) Process Heat

Emissions reductions are required in all areas of energy production and use. Industry commonly uses coal or gas for process heating. Modern nuclear reactors can produce process heat which can reduce emissions from industry. Wind and solar cannot provide process heat. Nuclear power not only reduces emissions from electricity generation, but also provides a pathway to emissions reductions in many other industries.

iv) Energy Density

Renewables, for example wind and solar, are very low energy density technologies, that is, the physical quantity of plant required for a given output is very high. The amount of concrete and steel in a wind turbine is more than 10 times the quantity in a nuclear power plant for a given output.[2] The NSW Nyngan solar plant has 1,350,000 PV panels on frames supported by 150,000 posts but produces only 102 MW peak output.

[2] 2015 US DOE Quadrennial Technology Review

v) Land Area

Wind and solar require large areas. For example, the new 150 MW Coleambally (NSW) solar plant occupies 550 hectares. This can be compared to a 720 MW NuScale plant that occupies only 18 hectares.

vi) Waste

The lifetime of a solar plant is around 25 years. By 2016, it had been estimated that 23 million solar panels had been installed in Australia. Reclaim PV (SA) has estimated that 100,000 - 150,000 PV panels every year are faulty and need replacing. The International Renewable Energy Agency (IRENA) has projected that by 2050 there will be up to 78 million tons of PV waste. Parts of PV panels can be recycled, but this requires the panels to be dismantled and the materials separated - an energy intensive process.

By comparison, a 720 MW 12 module NuScale SMR would produce each year only 120m^3 (two shipping containers) of low level waste that is packaged and stored in drums before being transported to a Low Level Waste repository.

The required repository is a simple, near-ground level engineered facility to hold the waste securely, usually in concrete cells, for around 300 years. A NuScale module would also produce only ~1500kg/year of used fuel which is initially stored in cooling ponds and then stored in dry casks on site or reprocessed. The final disposal of the small amount of waste from reprocessing or complete used fuel assemblies will be in a deep geological repository. Construction of this type of facility is in progress in Finland and is about to commence in Sweden and France.

vii) Decommissioning

There is extensive experience of decommissioning nuclear power plants, with more than 140 decommissioned worldwide. After operations cease, the fuel and coolants are removed. This takes about 2 years and removes the major radiation hazards - 99% of the radioactivity is in the used fuel. The plant buildings are then dismantled and the site remediated, leaving a greenfield site that can be reused.

There is an excellent example of decommissioning a research reactor in Australia. ANSTO's Moata research reactor at Lucas Heights operated from 1961 to 1995. The used fuel was removed after shutdown and sent back to the USA. In 2009/10 the reactor was completely dismantled. The concrete shielding was cut with a diamond saw and checked for radiation levels. Most of the concrete was able to be moved to landfill as industrial waste. The cost of dismantling was $4.15m. Considering that Moata operated for 34 years and laid the foundations of nuclear research in Australia, the cost of decommissioning is clearly a small proportion of the total project cost.

viii) Noise

Nuclear and PV produce very little noise during operation. Wind turbines produce significant noise which has an environmental impact and limits their siting. The noise of nuclear cannot generally be heard outside the plant boundary.

ix) Weather-dependency

Nuclear power plants operate regardless of the weather. They are designed to continue operating in extreme weather conditions. There are many examples in the USA where nuclear power plants have continued to supply electricity in extreme weather conditions, when other electricity generators have failed. PV panels can easily be damaged by storms and particularly by hail.

Renewables, by contrast, are totally weather-dependent. The output from a wind turbine rapidly decreases as the wind drops. Although this can be forecast to some extent, the drop can sometimes be quicker than expected. For example the AEMO report into conditions on 10 February 2017 (the very hot day in NSW) identified that the wind dropped faster than forecast, leading to a shortage of supply. According to AEMO, of more concern is the total cut-off of supply from a wind turbine when the high wind protection operates. In windy conditions, the turbine can suddenly de-load without warning. South Australia has over 1,600 MW of wind turbines, but the total output can be <10% for several days during calm conditions. The total output of **all** the wind farms in the NEM was less than 20% of their installed capacity for 2,760 hours (32%) during 2017.

Prerequisites for a nuclear power program:

- The *Australian Radioactive Waste Management Framework* is shown to effectively manage radioactive waste

<u>Topic D</u> Energy Affordability and Reliability

Affordability

Modern SMRs could be the lowest cost generation available in Australia because of their contribution to power system reliability.

The final cost of individual plants will depend on location-specific factors determined during feasibility studies. However, as with wind and solar energy, nuclear costs are coming down due to simpler and standardised design; factory-based manufacturing; modularisation; shorter construction time and enhanced financing techniques.

The 'whole of system' advantages of nuclear power has important strategic implications for the NEM and the entire economy.

Reliability

Modern nuclear power plants are reliable, dispatchable and safe, with capacity factors in excess of 90%.

SMRs with unit outputs of between 60 and 720 MW would be particularly suitable for the Australian power system. SMRs have features that will enable them to work effectively in a power system that has variable renewables.

The leading US example is the NuScale SMR. Up to twelve 60 MW modules can be accommodated in one power plant to provide a gross output of 720 MW. The NuScale plant is specifically designed to automatically adjust its output to compensate for the variable generation from wind turbines. The capacity factor of a NuScale module is >90%.

Load Following and Grid Operation

Modern SMRs are designed to "load follow" and can support weather-dependent renewables. They do not need to be connected to the grid for safety. On loss of grid, the NuScale modules can remain in operation and are then ready to contribute to re-establishing the grid. If a NuScale SMR had been operating in South Australia at the time of the September 2016 State blackout, the grid could have been restored quicker than it was. However, if an SMR had been operating in South Australia at the time, it is unlikely that the State blackout would have occurred.

Topic E Economic feasibility

Given their operating life of 60-80 years, it is likely that SMRs will be Australia's lowest-cost generation source.

The 2017 report by the US Energy Innovation Reform Project found that the costs for the new generation of advanced reactors would be much lower than for conventional nuclear power plants.

The US study found that the average levelised cost of electricity (LCOE) from advanced reactors was US $60/MWh. This would be $A75/MWh at today's exchange rates.

By comparison, the Finkel Report estimated LCOEs for other reliable technologies in 2020:

- Supercritical coal: A$76/MWh
- Gas CCGT: A$83/MWh
- Gas OCGT: A$123/MWh

In looking at the economics of different power generation options, it is essential to understand the distinction between generation costs and power system costs and to adjust for the low capacity factors, additional transmission cost and firming costs of renewable energy forms.

Electricity needs to be available on demand, 24 hours a day, 7 days a week and in all weather conditions (as explained under Weather-dependency above).

Nuclear is available 24 hours a day but solar, for example, may only be available for a third of the time each day. You must therefore multiply the generation cost of solar three times to get the same amount of electricity. Even then, it may not be available at the times of the day when it is required.

Although the generation costs of wind and solar are lower than nuclear, the true cost to the power system is higher. This is due to:

(i) their low capacity factor,
(ii) additional transmission costs and
(iii) firming costs.

Modelling by the Australian consultancy Electric Power Consulting of Kiama in 2018 showed that the cost of a system with 100% renewables would be more than 4 times the cost of a system where coal was replaced by nuclear [3].

A recent authoritative report (2019) by the OECD-NEA explains why the cost of electricity is increased by a high percentage of variable renewable energy (VRE) in the system[4].

Construction Time

Nuclear power plants were traditionally very large in order to capture economies of scale. In many cases, this has caused construction delays and increased costs. Modern SMRs will be factory-built and the complete reactor module is transported to site and installed with minimum on-site work. This reduces site construction time and the risk of expensive delays.

The actual time of construction of an SMR is planned to be around 36 months. This would be preceded by a period of around 4 years for community consultation, site selection, feasibility studies, environmental and development approvals and arranging financial facilities, making a total development period of around 7 years after the law is changed to lift the prohibition on nuclear power.

Prerequisites for a nuclear power program:

- feasibility study shows that a SMR could be economically viable

Topic F Community Engagement

The first NuScale SMR is planned to be sited near Idaho Falls, USA. This will be a 12 module, 720 MWe plant. The Idaho Department of Labour has forecast that the SMR will generate 12,800 local jobs during construction and 1,500 during operations.

The 1,000 direct construction jobs would create or support an additional 11,800 jobs through "inter-industry" trade and local services for the new workforce. NuScale expects direct construction jobs to peak at 1,100 employees and this would last for much of the three year site build.

The new plant will also support long term employment in Idaho Falls. NuScale expects the plant to directly employ 360 workers when it is online and the Department of Labour

[3] Electric Power Consulting https://epc.com.au/index.php/nem-model/
[4] The Costs of Decarbonisation: System Costs with High Shares of Nuclear and Renewables, NEA No7299, 2019

expects this will support 1,500 local jobs, equating to annual revenues of US$389 million for local industry in this regional area.

Prerequisites for a nuclear power program:

- Communities must be given sufficient time to fully satisfy themselves that the benefits of a nuclear power plant in their area outweigh any disadvantages

Topic G Workforce capability

Education is an important part of preparing for a nuclear power program. The University of New South Wales has been offering a Master of Nuclear Engineering Science (Nuclear Engineering) from 2013 and other universities include guest nuclear lectures in their energy programs. Also the Australian National University Master of Nuclear Science course was established in 2007 and includes nuclear reactors and the nuclear fuel cycle. When the government does decide that nuclear can be part of the low emissions energy mix, this will be an incentive for more courses to be offered.

The construction, commissioning and operation of ANSTO's new OPAL research reactor is a good example of how staff can be recruited, trained and become an efficient workforce. In addition to staff recruirted from overseas, young Australian engineering graduates were recruited and trained in nuclear operations whilst the reactor was under construction. They gained extensive operations experience during the commissioning process and Australia now has an expert cohort of nuclear engineers.

Australia is a very attractive country to live and work in. SMR Nuclear Technology Pty Ltd is regularly approached by nuclear engineers working overseas who would love to work in a nuclear program in Australia.

Prerequisites for a nuclear power program:

- Increased number of nuclear engineering courses in Australia

Topic H Security Implications

An important security issue is safeguards.
"Safeguards" is the total system for accounting for nuclear materials and are measures applied by the International Atomic Energy Agency (IAEA) to verify that non-proliferation commitments made by States under Safeguards Agreements with the IAEA are fulfilled. Because of our involvement in the nuclear fuel cycle and research reactors, Australia already has Safeguards Agreements in place. The Australian Safeguards and Non-Proliferation Office (ASNO), in the Department of Foreign Affairs and Trade is responsible for ensuring Australia's obligations for safeguards.

There are global and domestic security implications of nuclear power development.

At a global level, utilisation of nuclear power will reduce the vulnerability of individual countries to disruptions in oil supply and to volatility in oil prices. At a domestic level, nuclear power will not be prone to fuel supply shortages.

Prerequisites for a nuclear power program:

- Increase ASNO's resources for the additional workload.

Topic I National consensus

National support for properly-regulated nuclear power as part of the energy mix would contribute to community trust of energy policy and build national confidence in Australia's own long-term energy future and as supplier to our key trading partners of China, India and Japan.

Canada has made an early start on positioning itself to be the most innovative country in the modern nuclear industry. This is demonstrated by its publication in November 2018 of *'A Call to Action: A Canadian Roadmap for Small Modular Reactors.'*

The Canadian Roadmap starts by acknowledging nuclear energy as *'a strategic asset.'* Its declared purpose is '*to chart a vision for the next wave of nuclear innovation ... [because] SMRs could help Canadians achieve a low-carbon future.'* As it explains:

'Markets around the globe are signalling a need for smaller, simpler, and cheaper nuclear energy in a world that will need to aggressively pursue low-carbon and clean energy technologies to meet climate change goals.

SMRs respond to these needs: they are smaller nuclear reactors that involve lower capital investment and modular designs to control costs; they can compete with other low-cost forms of electricity generation; they incorporate enhanced safety features; and they could enable new applications, such as hybrid nuclear-renewable energy systems, low-carbon heat and power for industry, and offset diesel use in remote communities and mine sites.'

Topic J Other relevant matters: i) Lifting the moratorium on nuclear electricity generation ii) Drawing on IAEA support and iii) Joining the international NICE Future Initiative

I) Lifting the moratorium

With the lifting of the moratorium, it should be feasible to develop an initial 360 MW SMR nuclear generator by 2030 and up to 3000 MW by 2040.

The construction and operation of a nuclear power plant in Australia is presently prohibited by two Federal Acts:

- **Environmental Protection and Biodiversity Conservation Act (EPBC Act) 1999 S.140A**

- **Australian Radiation Protection and Nuclear Safety Act (ARPANS Act) 1998 S.10**

These prohibitions were put in place at a time when there was no real appreciation of the contribution that modern, safe nuclear power plants could make to energy security, affordability and emissions reduction.

In May 2016, the South Australia Nuclear Fuel Cycle Royal Commission recommended that prohibitions be removed:

> *Recommendation 8 - Pursue removal at the federal level of existing prohibitions on nuclear power generation to allow it to contribute to a low-carbon electricity system, if required.*

The legislative prohibitions preclude any serious consideration of the merits of nuclear power generation in Australia. SMR vendors will not treat Australia as a potential market whilst the prohibitions remain.

Although government reports have repeatedly endorsed the merits of "technology neutrality"in power system planning, the legislative prohibitions have prevented its accomplishment.

System reliability, as well as affordability and lower emissions, beyond 2030 can be underwritten by including load-following nuclear generation in the generation mix and allowing all technologies to compete with each other.

Modern SMRs could make a vital contribution to Australia's needs for reliable, low-emissions, affordable energy.

Without repeal of the legislative ban, Australia's power system will continue to be constrained at great cost to the economy.

ii) Drawing on IAEA support

The IAEA provides comprehensive guidance and support for the establishment of a nuclear power program in individual countries.

The IAEA Milestones Program[5] identifies the key infrastructure issues to be considered. Australia already has much of the infrastructure in place, for example the safeguards system, because of our involvement in the nuclear fuel cycle. A worthwhile supporting step for Australia could be the establishment of a Nuclear Energy Program Implementing Organisation (NEIPO) as recommended by the IAEA in its Milestones Program.

iii) Joining the NICE Future initiative

Australia is already one of nine countries that participate in some of the programmes carried out by under the ambit of the Clean Energy Ministerial (CEM) forum. In 2018, the CEM launched the Nuclear Innovation Clean Energy (NICE) Future Initiative. Australia would benefit by actively participating in this initiative, which conducts a dialogue on the role that nuclear energy can play in clean energy systems of the future. The "NICE Future" initiative seeks to addresses nuclear energy holistically within the context of broader clean energy systems, as opposed to a singular focus on specific nuclear technologies and associated issues.

Some Concluding Points

In the modern era, the nuclear industry is transforming itself to meet contemporary community expectations. In particular, modern SMRs are designed to be inherently safe and will provide reliable, affordable and low-emissions power for up to 80 years.

If the moratorium on nuclear power generation is lifted, SMRs could be deployed and become be a game-changer in Australian power system planning, progressively replacing obsolete power generators in the Australian power system as they close down over the next 30 years.

The development of nuclear power generation in Australian would lead to the establishment of an entire new industry with long-term environmental, technological, economic and social development benefits for the people of Australia and its internal regions. These benefits would flow on progressively to other industries.

[5] IAEA Nuclear Energy Series NG-G-3.1 Milestones in the Development of a National Infrastructure for Nuclear Power

Appendix A

Comparison of an SMR with a typical large power reactor (PWR) and ANSTO's OPAL Reactor

Parameter	Large Power Reactor	NuScale SMR	OPAL
Thermal output MWTh	3,400	160	20
Gross electrical output MWeGross	1,200	60	0
Number of fuel assemblies	193	37 (half height)	16
Mass of uranium tonnes	96	9.23	39 kg
Containment inner diameter metres	43	4.32	N/A
Containment height metres	62	23	N/A

It is clear that an SMR would be closer in size to the existing OPAL reactor at Lucas Heights than a typical modern large power reactor

Apppendix B

SMR Cost Estimates

A modern SMR has not yet been constructed and therefore any cost figures can only be estimates.

The contract for the first deployment of the NuScale SMR in the USA is expected to be signed in the next two years and this will give a better indication of costs, although this will be FOAK (First of a Kind) deployment and subsequent deployments (NOAK) would be expected to cost less.

A feasibility study would be required to determine the costs in Australia.

The table below shows cost estimates.
The AEMO/CSIRO GenCost 2018 report includes the latest cost estimate (report Fig 2.1) for an SMR in Australia. This is considerably higher than any other cost estimate. Also unlike other technologies the learning rate out to 2050 is practically zero (Fig 3.9).
AEMO/CSIRO contracted GHD to supply cost estimates for their report. GHD decided to provide an estimate (GHD Report for AEMO Table 58) for a future Gen IV reactor to be constructed in 2035, rather than the type of SMR (eg NuScale) that will be deployed in the early 2020s and is based on known technology. The GenCost 2018 figure is therefore not a realistic cost of an SMR that would most likely be deployed in Australia.

The other recent Australian SMR estimate was produced by Parsons Brinkerhoff in 2015 for the SANFC Royal Commission. Because there was a lack of information about SMR costs, Parsons Brinkerhoff used the cost of a very expensive USA PWR and added 5%, with 10% WACC. This estimate again is not realistic for a current SMR in Australia.

The NuScale cost estimates were produced by Fluor on a rigorous and systematic 'bottom up" approach conforming to Americal Association of Cost Engineers class 4 cost estimates. The best estimate for Australia would be NuScale NOAK cost, adjusted for Australian conditions. We emphasise that a proper feasibility study would be essential for any Australian project.

Source	Cost $/kW installed capacity	LCOE $/MWh	Notes
NuScale FOAK	US$4,350/kW		2017 USD 683 MWeNett
NuScale NOAK	US$3,600/kW		2017 USD 683 MWeNett
Energy options network USA	US$3,782/kW	US$60/MWh	2017 Average for advanced reactors
2017 SMR Start Economics of SMRs	US$5,150/kW		400 MWe (2x200 MWe) deployed in 2026
AEMO/CSIRO GenCost 2018	A$16,000/kW	A$250/MWh	GHD report based on Gen IV 300 MWe reactor constructed in 2035
Parsons Brinkerhoff for SANFC Royal commission	A$11,689/kW	A$225/MWh	2015 Based on large US PWR +5%, 10%WACC Greenfield site
Canadian SMR roadmap		CDN$70/MWh =(A$76/MWh)	2018 average SMR

This submission includes two Appendices addressing Scale and SMR Cost Estimates. It replaces an earlier submission dated August 2019.

SMR Nuclear Technology Pty Ltd has been pleased to provide this submission to the House of Representatives Standing Committee on the Environment and Energy and stands willing to expand on these and any other issues that the Committee may wish to raise in evidence to the Committee.

Tony Irwin
Technical Director
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