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

The Senate Environment and Communication Legislation Committee inquiry into the Environment and Other Legislation Amendment (Removing Nuclear Energy Prohibitions) Bill 2022

January 2023

EXECUTIVE SUMMARY

The objective of the prohibitions is to protect the health and safety of people and to protect the environment from the harmful effects of radiation.

The fundamental question is - if the prohibitions were removed would people still be protected from the harmful effects of radiation?
International and Australian experience is that people and the environment would still be protected. This is because of the internationally accepted standards established by the International Atomic Energy Agency (IAEA) plus the strong, independent nuclear and environment regulators. In Australia's case, the nuclear regulation 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.

Australia has over 60 years' experience in safely deploying nuclear technology, including 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

Removal of the prohibitions would enable all low emissions technologies to be considered when formulating energy policies.

In May 2016, the final report of the South Australia Nuclear Fuel Cycle Royal Commission recommended that the 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.

Australian Radiation Protection and Nuclear Safety Act 1998

The object of the ARPANS Act is "to protect the health and safety of people, and to protect the environment, from the harmful effects of radiation" (ARPANS Act Section 3)

Section 10 of the ARPANS Act contains the prohibitions:

10 Prohibition on certain nuclear installations
(1) Nothing in this Act is to be taken to authorise the construction or operation of any of the following nuclear installations:
(a) a nuclear fuel fabrication plant;
(b) a nuclear power plant;
(c) an enrichment plant;
(d) a reprocessing facility.

The fundamental question is - if the prohibitions were removed would people still be protected from the harmful effects of radiation?
International and Australian experience is that people and the environment would still be protected.
The International Atomic Energy Agency (IAEA) based in Vienna was established in 1957 and provides guidance on protection. The IAEA Safety Standard *Government, Legal and Regulatory Framework for Safety GSR Part 1* establishes the responsibility of governments and regulatory bodies. It emphasises the importance of an independent regulator with the competences, resources and authority to fulfil its statutory obligations
In Australia, the Australian Radiation and Nuclear Protection Agency (ARPANSA) was established in 1999 in accordance with the IAEA best practice and is recognised as a world-class regulator. ARPANSA provides the necessary strong regulatory controls. ARPANSA was audited by the IAEA International Regulator Review Team (IRRT) in 2007 with a follow up mission in 2011 and a further full review planned for 2023.

In addition, Australia is a party to all the major international nuclear conventions including:

- Convention on Nuclear Safety
- The Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management

The prohibitions were included in the Acts before Australia had adopted all the international conventions on nuclear safety and before there was an understanding of the importance of reducing greenhouse gas emissions and the part that nuclear power plays internationally in the reduction of emissions.

Removal of the prohibitions would enable the consideration of all low emissions technologies when formulating Australia's energy policy.

Environment Protection and Biodiversity Conservation Act 1999

The objects of this Act are:

(a) to provide for the protection of the environment, especially those aspects of the environment that are matters of national environmental significance

The prohibitions are listed in section 140a of the EPBC Act:

140A No approval for certain nuclear installations

The Minister must not approve an action consisting of or involving the construction or operation of any of the following nuclear installations:

(a) a nuclear fuel fabrication plant;

(b) a nuclear power plant;

(c) an enrichment plant;

(d) a reprocessing facility.

These are the same prohibitions as the ARPANS Act.

The Important areas to consider are the safety of nuclear power plants, the management of radioactive waste, and environmental impacts and these are examined in more detail:

I. 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. There has not been an accident leading to a radioactive release offsite from any reactor built in the last 35 years.

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. A modern nuclear power plant would have survived even the extreme Fukushima accident.

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.

II. 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 924 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. it has a number of engineered 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.

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.

III. Environmental Impacts

The environmental impacts of nuclear power are less than those of wind and solar. This is because of the high energy density and longer lifetime of nuclear compared to wind and solar. High energy density requires less materials and less land area per unit of electricity

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

generated. Longer lifetime requires less replacement. The design lifetime for nuclear power plants is 60 years, solar design is 25 years and wind design is 20 years. All the existing solar and wind plants will have to be replaced before 2050. Sustainability is increasing recognised as an important consideration in energy policy.

The objective of the EPBC Act is to protect the environment. The deployment of nuclear power in Australia would support this objective.

The individual aspects of this are explored in the next sections.

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 UN Intergovernmental Panel on Climate Change (IPCC) produces figures for whole of life cycle emissions for different electricity generation technologies. The median value for nuclear is 12g/kWh, the same as wind. Solar is higher at 48 g/kWh. The latest United Nations Economic Commission for Europe (UNECE) report shows nuclear lifecycle emissions have reduced to 5.1 – 6.4 g/kWh due to changes in uranium mining techniques and less energy intensive enrichment technologies.

In 2021, 2,653 TWh was generated by nuclear power reactors worldwide (more than ten times the total Australian electricity generation), saving over 2 billion tonnes CO2-e emissions (World Nuclear Association).

In 2020/21, Australia exported 6,166 tonnes of uranium oxide concentrate (ASNO Annual Report[2]) which would have generated ~262 TWh and saved the recipient countries more than 200 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 2014 were 180 million tonnes CO2-e (National Greenhouse Gas Inventory).

[2] https://www.dfat.gov.au/publications/international-relations/asno-annual-report-2020-21/asno/section-2-3.html

Six years later, and after billions of dollars spent on wind and solar, Australia's annual emissions from electricity generation for the year 2020 were 172 million tonnes CO2-e.

Australia has one of the world's highest emission intensities for electricity generation, typically ~700g CO2-e /kWh (AEMO). Countries with consistently low emissions intensities either have large hydro resources (Norway) or have nuclear as part of their energy mix (France, Belgium).

No country has consistently 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.[3] The 275 MWac Darlington Point (NSW) solar plant has 1 million PV panels but produces only 685 GWh/year (Edify website). A 275 MW nuclear plant would supply 2,288 GWh/year.

v) Land Area

Wind and solar require large areas. For example, the 275 MWac Darlington Point (NSW) solar plant occupies 1,000 hectares, requiring 1,460 hectares/TWh of electricity generated. By comparison, a 924 MW NuScale plant occupies only 18 hectares, equivalent to 2.4 hectares/TWh.

vi) Critical Materials

Nuclear requires much less quantities of critical materials than wind or solar (IEA "The Role of Critical Materials in Clean Energy Transitions, May 2021).

Wind average 10,000 kg/MW, critical materials copper, zinc, manganese, chromium, nickel, molybdenum, rare earths.

Utility scale solar average 7,000 kg/MW, critical materials silicon, copper, silver

Nuclear average 5,000 kg/MW, critical materials chromium, copper, nickel.

Also, particularly for solar, the supply chain for processed minerals is dominated by one country – China.

[3] 2015 US DOE Quadrennial Technology Review

vii) 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 and expensive process.

By comparison, a 924 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.

viii) 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.

ix) 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.

x) 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. Solar panels can also be covered by sand storms, or snow.

Renewables 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 1,900 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.

Conclusions

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.

SMR Nuclear Technology Pty Ltd has been pleased to provide this submission to the Senate Environment and Communications Legislation Committee and stands willing to expand on these and any other issues that the Committee may wish to raise in evidence to the Committee.

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January 2023