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A Submission by SMR Nuclear Technology Pty Ltd (SMRNT) to the Australian Government's Department of Industry, Science, Energy and Resources Technology Investment Roadmap Discussion Paper, June 2020

KEY POINTS

Through modern nuclear power, Australia will be in a position to completely and sustainably transform its entire economy. This could provide an economic and environmental miracle for the nation.

Deployment of the first modern SMRs has started worldwide. Australia cannot wait until 2030 to start monitoring overseas developments in SMRs - we must start now.

Modern nuclear power, safely produced by modern small modular reactors (SMRs) such as the 720 MW NuScale Power plant of the USA, could:

i. progressively eliminate all emissions from the national energy system

ii. counteract the weather-dependency of other low-emissions energy sources

iii. increase national energy security

iv. establish a new high-technology industry, generating 12,800 construction jobs for each new plant (State of Idaho estimates for first NuScale deployment)

v. provide a source of process heat for hydrogen production and

vi. be strategically located to support many other industry sectors.

With a first plant commencing construction in 2026 and completing construction in 2030, a total of six plants in all mainland States could be producing 4320 MW of low-emissions electricity for the national grid by 2040, transforming and strengthening the entire economy and contributing to the global environmental good.

ANSTO already provides a source of expertise for Australia's nuclear industry.

A modern regulatory system is already in place under the auspices of the Australian Radiation Protection and Nuclear Safety Agency.

There are only four practical technologies available for low-emissions power systems: hydro, solar, wind and nuclear power.

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

The heat output from nuclear power reactors can also be used to provide low- emissions process heat for production of hydrogen, an important element of Australia's low-emissions future.

Nuclear power is also able to provide a low-emissions source for maintaining batteries and pumped hydro.

However, none of these ambitions can be pursued until Australia removes its legislative prohibition on nuclear power.

Lifting the legislative barrier against nuclear power in Australia would bring about an economic, industrial and environmental miracle for the nation by 2040 – a decade ahead of the global 2050 net zero target.

1. Deployment Pathways for SMRs

Modern SMRs are multipurpose.

There are several deployment pathways for electricity generation, for example:

- Larger SMRs can be deployed for coal fired power station replacements. The NuScale (USA) SMR 12 module plant generates 720 MWe and would easily fit on any existing site as it only occupies 18 hectares
- Smaller SMRs can be deployed at remote mine sites or supply remote communities
- They provide a source of supply for mission critical facilities
- All SMRs supply the grid system with inertia and frequency control
- Modern SMRs can load follow and work in a system with variable renewable energy (VRE).

In addition to electricity generation, SMRs can be deployed in many industrial roles:

- Desalination
- Process heat, particularly for efficient hydrogen production

2. Electricity Generation

Modern SMRs are reliable, dispatchable and safe, with capacity factors in excess of 90%. They are designed to load follow to work in a system with VRE.

The advantages of SMRs have been described in detail in the SMR Nuclear Technology Pty Ltd submissions to the 2019 Federal nuclear inquiry[1], the NSW nuclear inquiry[2] and the 2019 Victoria inquiry into nuclear prohibitions[3].

The South Australia Nuclear Fuel Cycle Royal Commission, Federal nuclear inquiry and NSW nuclear inquiry reports all confirmed the suitability of SMRs for Australian conditions.

In addition to electricity generation, SMRs can also provide the important grid system services of inertia and frequency control - essential for grid stability.

The Technology Investment Roadmap includes “Monitor and consider overseas developments in small modular reactors” but only in the long term 2030-2050.
As recommended by all the nuclear inquiries, this monitoring and consideration should start immediately.

[1] Submission 39 to The House of Representatives Standing Committee on the Environment and Energy Inquiry into the Prerequisites for Nuclear Energy in Australia, August 2019
[2] Submissions 4 and 4a to the NSW INQUIRY INTO URANIUM MINING AND NUCLEAR FACILITIES (PROHIBITIONS) REPEAL BILL 2019
[3] Submission 40 to the Victoria Legislative Council’s Environment and Planning Committee, Inquiry into nuclear prohibitions

Our recent report[4] identified that there are two SMR reactors operating now, three under construction and many more at an advanced stage of licensing.

Most SMR technology is a scaled-down, modular version of a mature technology known as light-water reactor (LWR) technology that has been successfully deployed around the world for over 70 years. The detailed design of NuScale's SMR is presently in the final stages of a four-year process of regulatory approval by the US Nuclear Regulatory Commission that is expected to be completed in 2021. The construction site has been chosen at the Idaho National Laboratory (INL) in Idaho, USA, and the new plant is expected to be fully operational in 2026.

The US Department of Energy has agreed to draw from two modules of NuScale's twelve-module SMR plant for the purposes of the Carbon Free Power Project (CFPP) conducted by the Utah Associated Municipal Power Systems. One module will be set aside for research activities (known as the Joint Use Modular Plant or JUMP program). The research is mainly focussed on integrated energy systems that support the production of both electricity and non-electric energy products, particularly hydrogen. The other module will sell power to INL.

The NuScale SMR features a passive safety systems approach and other design features that are intended to provide unmatched safety performance. Distinctions include the use of natural circulation of reactor coolant, a high-strength steel containment, and an integral reactor vessel that eliminates over two thirds of the safety systems and components found in today's large reactors.

It would be of clear advantage to Australia to become familiar with the US research activities at the earliest possible date.

The Parliamentary inquiry reports have confirmed that Australia should start preparing for possible deployment of nuclear power by ensuring that all the necessary infrastructure and arrangements are in place. The IAEA Milestones guide[5] is a valuable source of guidance. Australia Is a long-established member of the IAEA and would receive advice from experts with recent experience of the introduction of nuclear power to new countries.

Although 100% renewable electricity generation may be technically possible, the large overcapacity, firming capacity and additional transmission required may make this option more expensive than other options that utilise a range of generation technologies including nuclear. The OECD-NEA has explained why the cost of electricity is increased by a high percentage of variable renewable energy (VRE) in the system[6].

[4] SMR Global Status Report April 2020 available at http://www.smrnuclear.com.au/wp-content/uploads/2020/04/SMR-GLOBAL-STATUS-REPORT-APRIL-2020_v4KP.pdf

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

[6] The Costs of Decarbonisation: System Costs with High Shares of Nuclear and Renewables, NEA No7299, 2019

3. 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 directly. Nuclear power not only reduces emissions from electricity generation, but also provides a pathway to emissions reductions in many other industries.

Australia is looking at hydrogen as a key fuel for the future. This relies on the efficient and economic production of hydrogen. In his address to the Press Club on 12 February 2020, Chief Scientist Alan Finkel stated that "There's a nearly A$2 trillion global market for hydrogen come 2050, assuming that we can drive the price of producing hydrogen to substantially lower than A$2/kg." Process heat increases the efficiency of hydrogen production. Renewables cannot produce process heat, but nuclear reactors do, particularly the Gen IV types like the Terrestrial Molten Salt Reactor which supplies process heat at 600^{o}C for high temperature electrolysis. This enables hydrogen production at a cost comparable to steam methane reforming, but with low emissions and a cost less than one third of renewable energy electrolysis (Terrestrial submission 260 to Federal Nuclear Inquiry).

The NuScale Power (USA) SMR is in the final stages of licencing by the US Nuclear Regulatory Commission (NRC). The NuScale Power module is rated at 60 MWe and the standard plant has up to 12 modules providing 720 MWe.

NuScale has studied the multipurpose use of their SMR. Studies have been completed of:

- Desalination - 8 module plant producing 190Km^3/day of clean water + 350 MWe (water and electricity for 300,000 people)
- Hydrogen production - 6 module plant for high temperature steam electrolysis
- Oil refinery - 10 module plant coupled to a 250,000 barrels/day refinery
- Integration with wind - one module dedicated to an existing 57.6 MWe wind farm

4. Hydrogen Production by Nuclear Power

The efficiency of hydrogen production by electrolysis can be improved, hence reducing costs, by increasing the production temperature by the use of process heat from a nuclear power reactor. Process heat is produced at high efficiency because the losses associated with the Rankine cycle turbine condenser are avoided. The higher temperature also avoids the need for expensive catalysts. Thermal energy is cheaper than electrical energy.

The nuclear reactors would be operated at full power and generate electricity as required or use the excess heat for hydrogen production. The plant would produce two products - hydrogen and electricity.[7]

[7] R. Boardman, INL; Evaluation of Non-electric Market Options for a light-water reactor in the Midwest (Light Water Reactor Sustainability Market Study, March 2019

In June 2020, The US DOE announced up to $3.5m for hydrogen production R&D that is compatible with nuclear energy sources.[8]

Temperatures of electrolysis technologies[9]:

- Alkaline electrolysis (AE) 50-80^{o}C
- Proton Exchange Membrane (PEM) 20 - 90^{o}C
- Solid Oxide Electrolysis cell (SOE) 700 - 1,000^{o}C

An SMR light water reactor produces heat suitable for AE and PEM.
A molten salt SMR directly produces heat suitable for SOE.

A study by NuScale Power, Fluor, Aquatech International and Idaho National Laboratory[10]of heat and electrical power produced by a 160 MWTh NuScale Power Module (NPM) directly routed to a High Temperature Steam electrolysis (HTSE) unit operating at 800^{o}C demonstrated that one NPM could produce 1,310kg/hr hydrogen 99% pure. A small amount of electrical power (1.15 MWe) from the NPM was needed to boost the inlet temperature of the HTSE feed steam to 800^{o}C and the balance of electricity was used to electrolyse the high-pressure steam/hydrogen mixture. A medium-scale hydrogen production plant of about 200 tons/day hydrogen would require 6 NuScale modules.

5. Flow-on Benefits – Jobs

NuScale's first SMR will be near Idaho Falls, USA. It is 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 305 workers when it is online and the Department of Labour expects this will support 1,500 local jobs, equating to annual revenues of US$389 million for local industry in this regional area.

[8] Energy Department Announces up to $3.5M for Nuclear-Compatible Hydrogen Production | Department of Energy
[9] CSIRO 2016 Cost Assessment of Hydrogen production from PV and electrolysis
[10] Extending nuclear energy to non-electrical applications, Pacific Basin Nuclear Conference 2014

6. Australia's R&D Strengths

Australia's has world-class expertise in nuclear technology, and this is one of our R&D strengths. ANSTO is recognised globally as a leading research establishment and is particularly involved in the research into materials for new nuclear reactors. This research has applications in other areas, for example the molten salt work can be applied to both solar thermal and molten salt storage technologies.

Australia (represented by ANSTO) is a member of the *Gen IV Forum*[11], a group of 13 major nuclear countries leading the research effort for the next generation of nuclear reactors.

7. Conclusions

Modern nuclear power, most specifically SMRs, is the perfect partner for VRE in modern power systems. As requirements arise for new generation capacity in the NEM, SMRs can be brought on line to provide a safe, affordable and sustainable alternative. Australia could lead the world in its deployment of this unique technology.

Australia already has a strong regulatory system. This will provide the community with the confidence that it needs to set a new world standard for safe, affordable and emissions-free electricity.

Deployment of the first modern SMRs has started worldwide. We cannot wait until 2030 to start monitoring overseas developments of SMRs - we must start now.

A decisive move at this time to remove Australia's obsolete ban on nuclear power could be the start of an economic, social and environmental miracle for the nation.

SMR Nuclear Technology Pty Ltd has been pleased to provide this submission to the Department of Industry, Science, Energy and Resources and offers to expand on all issues referred to.

Tony Irwin
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[11] Gen IV Forum - https://www.gen-4.org/gif/jcms/c_60638/generation-iv-international-forum-overview