December 12, 2022

Committee Secretary
Senate Standing Committees on Environment and Communications
PO Box 6100
Parliament House
Canberra ACT 2600

This letter is submitted for consideration by the Committee in relation to the *Environment and Other Legislation Amendment (Removing Nuclear Energy Prohibitions) Bill 2022*. It is submitted in response to a request for comment issued by the Committee.

Based on the record of 64 years of safe nuclear reactor operations at Lucas Heights, NSW, demonstrating confidence in the ability to regulate, construct and operate such devices, it is suggested that the Committee amend current legislation to allow the *construction and operation of nuclear power plants in Australia that have thermal output of less than 100 MW*.

Detailed input is appended to this letter.

Thank you for the opportunity to present these comments.

Sincerely,

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[redacted]

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Input to the Senate Standing Committees on Environment and Communications

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Based on the record of 64 years of safe nuclear reactor operations at Lucas Heights, NSW, demonstrating confidence in the ability to regulate, construct and operate such devices, it is suggested that the Committee amend current legislation to allow the *construction and operation of nuclear power plants in Australia that have thermal output of less than 100 MW*.

Australia's first large reactor – HIFAR – had a thermal output of 10 MW. It's replacement – OPAL – has a thermal output of 20 MW. USNC recommends that the Committee consider that there is a track record in Australia for using small reactors, and that these do not impose financial risks that some larger systems present.

This submittal presents the case for Australia to change the law to allow the development of civil nuclear power reactors that are similar in size to the current OPAL reactor operating in suburban Sydney. Micro modular reactors (MMRs) are developed and deployed by the Ultra Safe Nuclear Corporation (USNC). The MMRs are targeted at replacing large diesel-fueled generators in Australia, located at remote resource facilities, strategic operations, and populations that are disconnected, or at least poorly connected, to the grid.

The replacement of remote and isolated oil, diesel and gas electrical generators in Australia with MMRs would be transformational and have the following benefits:

- ***MMRs Improve the Strategic Security of Australia***
- ***MMRs reduce 5% of the annual emission of carbon dioxide.***
- ***MMRs create 500,000 person-years of additional employment for Australia.***
- ***MMRs reduce pollution and improve public health outcomes for Australia.***
- ***MMRs make significant contributions to the Australian economy and taxes.***
- ***MMRs enables green hydrogen production at remote facilities.***

These attributes can be delivered to Australia without the expenditure of any public funds while reducing the cost of energy delivered to the remote facilities and communities.

<u>Australian Prohibition</u>

In 1998 and 1999, the Australian Parliament banned civil nuclear power with the passage of the *Australian Radiation Protection and Nuclear Safety Act* and the *Environment Protection and Biodiversity Conservation Act*. The former revised the nuclear regulator's mandate - the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) - to include "prohibition of certain nuclear installations". The latter included the mandate that "The Minister must not approve an action consisting of or involving the construction or operation of a….nuclear power plant".[i]

Parliament, however, has authorized the construction of the OPAL reactor, a research and isotope production facility, located in suburban Sydney (Lucas Heights) at the Australian Nuclear Science and Technology Organisation (ANSTO). Only recently, the Government has announced the acquisition plans for nuclear-powered submarines. The prohibition for civilian nuclear power remains in legislation.

In recent years, there have been calls to remove the prohibition. The Minerals Council of Australia has been outspoken in its message to remove the ban. Many have suggested the need to remove the ban to achieve a reduction of carbon emissions. The Australian Workers Union has publicly expressed its support for consideration of civilian nuclear power.

The Micro Modular Reactor (MMR)

Ultra Safe Nuclear Corporation (USNC) has developed the MMR which is about the size of the OPAL reactor at ANSTO in suburban Sydney.[ii] A sketch of the MMR is shown below. Items relevant to the MMR follow:

- USNC has been contracted to construct the initial MMR at Chalk River, Ontario, Canada. The second reactor will be constructed and operated at the University of Illinois Urbana Champaign. Many dozens of reactor orders are being negotiated for deployment in Europe, Canada, the United States and Asia. The first reactor will be operational in 2025.
- The MMR is produced in three versions, generating up to 20 MWe.[iii]
- The MMR is extremely safe:
  - It cannot melt down;
  - It cannot explode;
  - Being cooled by helium, a complete loss of coolant is not possible because air could continue to circulate and remove heat; and
  - A minimal exclusion[iv] zone for protection of the public has been established to be 50 meters by the Canadian Nuclear Safety Commission (CNSC).

- Wastes from the MMR can be managed within the low-level waste disposal facilities in Australia and within the spent fuel disposal approach being assessed by CSIRO.
- Once licensed, the MMR can be constructed in between 18 and 24 months.
- The MMR is fully dispatchable. This means that it can operate at very low energy output, at full power, or at any level in between.
- The MMR will operate for up to 20 full-power years before refueling.
- The MMR can be fully integrated with renewables by storing thermal energy in molten salt which becomes a thermal battery. This enables a station comprised of MMRs and renewables to deliver baseload or peaking power.
- The MMR can be fully integrated with beneficial systems such as hydrogen and ammonia production, food security through sealed greenhouses or vertical farming, or clean water production through desalination.

Electricity Generation in Australia Using Oil, Diesel and Gas Generators

While precise statistics are not published, Australia operates over 5,000 MWe of electricity generation systems fueled by oil, diesel, gas and coal mine gas. These generators are typically situated at remote mineral resource facilities, at remote strategic defence facilities, and at small, isolated communities.[v]

MMRs are suitable for replacing remote, isolated electricity generation systems. The benefits of this replacement are enumerated later in this paper. The majority of the remote generators being discussed here operate in generating units of between 20 and 100 MWe. Only a few of diesel stations exceed 100 Mwe.[vi] Accurate estimates of the cost of diesel-based electricity generation range between US$0.25 and US$0.35 per kwhr. [vii] The cost of oil-fueled electricity generation is similar to that for diesel using internal combustion engines. The cost of electricity generated with gas and coal-seam gas varies depending on the situation. Using the cost of US$0.25 per kwhr, at current exchange rates, Australians and local industry spends A$15 billion per year for electricity from these smaller stations. It is likely that the value is much higher.

Some relevant data about the generation of electricity in Australia using diesel generators follows:

- In the financial year of 2020-2021:[viii]
  - Australia imported 22.7 billion liters of diesel, generated another 5.9 billion liters of diesel bringing the total consumption to 28.6 billion liters. For comparison, this is enough diesel to fill the MCG 14 times, or to fill 11,000 Olympic swimming pools.
  - The diesel imported came from China (20%), Brunei, Taiwan, India, Japan, Korea, Malaysia, Singapore and Indonesia.
- In broad terms, Australia maintains a strategic supply of diesel equal to between 17 and 25 days.[ix]
- The current consumption of diesel to generation electricity is estimated to be 8 billion liters per year, or about 28% of the total domestic consumption of diesel.[x]

MMRs Improve the Strategic Security of Australia

- Diesel: MMRs can reduce Australia's dependence on diesel imports:
  - Up to 35% of Australian diesel imports and 28% of total annual diesel consumption can be reduced by MMRs.
  - With no other changes, Australia's strategic supply of diesel can be extended by 90 days by allowing MMRs to be deployed.
  - With MMRs, Australia could reduce or eliminate diesel imports from countries that are unfriendly without impacting any security parameter.
- Nuclear Skills and Technology: Allowing MMRs to be deployed will develop nuclear engineering capabilities that will enhance the nation's security and transition to nuclear-powered submarines.
  - MMRs, being roughly the same size of the OPAL reactor, build upon the 64-year history of safe and successful nuclear plant regulation and operations at ANSTO in suburban Sydney.
  - MMRs will introduce engineering, manufacturing, operations and scientific know-how to Australia in nuclear technology, this being critical to the deployment of nuclear-powered submarines, at no cost to the Government.
- Secure Power for Critical Facilities: MMRs can provide secure power for remote, strategic facilities in Australia.
  - MMRs can provide on-site, economic, independent, dispatchable, long-term, secure and carbon-emission free energy supplies instead of diesel, to enhance security at remote strategic facilities.
  - Deploying MMRs at remote strategic facilities protect Australia from acts of terrorism, international intervention or natural causes by altering the need for diesel imports and delivery, and by removing dependence on limited grid connections.
- Secure Power for Remote Populations: Remote communities can have secure energy by coupling MMRs with renewable energy providing enhanced community outcomes.
  - MMRs deployed in remote communities can reduce the vulnerability to disruption of diesel delivery.
  - MMRs can be fully integrated with renewable energy sources so that remote communities are not impacted by the known intermittency of renewable energy sources and to reduce land use.
  - MMRs enhance strategic outcomes for remote communities including energy for medical purposes, communication, clean water, sanitation, food preservation, education and community development.
- Reduced Dependence on Foreign Intervention: Deploying MMRs supports energy independence and reduces vulnerability to the actions of foreign governments.
  - MMRs can reduce Australian dependence on oil imports, thus improving security.
  - MMRs can provide energy to strategic resource and defence facilities during a period of foreign intervention, thus enhancing national security.

MMRs could reduce the annual emission of 20 million tonnes of carbon dioxide.

- Replacing 3,000 MW of diesel-powered electricity generation with MMRs could reduce Australia's carbon emission by 20 million tonnes per year, which is 5% of the annual emission.[xi]
- Additional reductions of carbon emissions are realized by eliminating the releases from reduced domestic refining as well as diesel delivery to remote operations.
- Thus Australia can reduce its carbon emissions by 5% per year without any expenditure of tax money or without any direct cost to the Australian consumer (see later discussions on economics).

Allowing MMRs to be deployed create 500,000 person-years of additional employment for Australia.

- The replacement of 4,500 MWe of diesel generation with MMRs would generate 90,000 person years of direct employment in Australia, without consideration of increased employment due to industry efficiency.[xii] This employment is largely construction, manufacturing and operations staff, this being an ideal stable labor base for organized labor.
- In addition to the direct employment that results from MMR deployment, an additional 420,000 person-years of employment is generated in Australia.[xiii]

Deploying MMRs reduces pollution and improve public health outcomes for Australia.

- Deploying MMRs to replace diesel generation of electricity results is a material reduction three air pollution components – NOX, PM10 and PM2.5. The reduction of particulate emission is approximately 5 million kg per year.
- Public health will improve through the reduction of these pollution components.[xiv]

Allowing MMRs to be deployed makes significant contributions to the Australian economy.

- Deploying MMRs could produce at least A$5 billion per year in increased profits for companies or reduced costs for communities.[xv]
- MMR use would generate A$2 billion in carbon credit revenue under EU rules, increasing the annual Australian savings to US$7 billion per year. [xvi]
- If these savings (A$7 billion per year) were all corporate savings, then this would:
    - Increase annual corporate profits by up to A$7 billion per year
    - Increase dividends to shareholders
    - Increase tax collections by A$1.6 billion with increased profits[xvii]
    - Improve cost competitiveness of Australian industry
    - Improve employment for Australian industry
- The creation of 500,000 person-years of employment directly and indirectly associated with MMR development could generate A$20 billion in new payroll tax revenue over the development period.[xviii]

- The deployment of MMRs would create new corporate bond options for institutional investors.[xix]
    - The anticipated developments would have a capital cost of A$90 billion.
    - Corporate bonds, ***guaranteed by the US government***, would provide the finance for these plants.
    - This would:
        - Provide $90 billion in high quality investment bonds.
        - Increase returns to investment portfolios.
        - Increase income to bondholders.
        - Increase tax collections.
- Annual reduction of A$3 billion in diesel fuel consumption tax rebate, based on A$0.40 per liter.
- Where MMRs are deployed in remote communities, electricity generation costs are lower than renewables integrated with batteries, particularly considering the total capital deployment needed to counter intermittency factors.
- As MMRs would be generally deployed by private corporations, their financing would not become public debt.

MMRs can enhance green hydrogen production at remote facilities.

- MMRs can produce very high quality, superheated steam due to the operating temperature of the salt thermal battery. This is a key ingredient to the production of hydrogen.
- Given that hydrogen is very difficult to transport, MMRs can be used to produce hydrogen at remote defence and resource sites to hasten the transition away from fossil fuels.
- USNC is working with one Australian corporation to enable the production of up to 500,000 T of hydrogen per year from a single MMR. Without a change in the law, this technology will be matured in other countries and will not contribute to the moves to a hydrogen economy.

Radioactive material associated with MMRs can be safely transported.

- All regulated material associated with the MMRs will be transported in containers certified to the highest global safety standards.
- There has never been an accident involving the shipment of the highest level of nuclear material that has resulted in a leak.

Radioactive wastes from MMRs will be safely managed within Australia.

- Low-level radioactive wastes produced by MMRs will be safely managed at the Australian National Radioactive Waste Management Facility currently being developed in South Australia.
- Spent nuclear fuel from MMRs can be safely managed in very deep boreholes, currently being examined by CSIRO, or in mined repositories such as are being developed in Sweden and Finland.

- MMR radioactive wastes are equivalent to wastes currently being produced in Australia and which will be produced by Australia's new nuclear-powered submarine fleet.
- The cost of radioactive waste disposal is included in all of USNC's economic projections contained in this submission.

MMRs are proliferation resistant.

- MMRs do not increase the likelihood that fissile material can fall into the hands of terrorists. The fissile material is locked into a chemically-robust structure.
- MMR spent nuclear fuel is resistant to being diverted for clandestine use.

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[i] *Removing the Prohibition on Nuclear Power*, Minerals Council of Australia, September 2017, see https://www.minerals.org.au/sites/default/files/180605%20Removing%20the%20prohibition%20on%20nuclear%20power.pdf.

[ii] ANSTO reports that the *Open Pool Australian Lightwater* (OPAL) reactor is a state-of-the-art 20 megawatt multi-purpose reactor.

[iii] Throughout this document the abbreviation MWe is used to signify megawatts of electricity. This is used to distinguish between the total thermal energy generated by the reactor, designated MWth versus the electrical output.

[iv] Nuclear regulators establish an exclusion zone around nuclear power plants. This zone is determined to be the minimum distance that the nuclear power plant must be removed from the public. It is common for such zones to be 1 km or more. By establishing the nuclear exclusion zone to be 50 m, the direct conclusion is that no scenario has been identified that would cause radioactive material to be released from the MMR.

[v] A list of Australian generation systems fueled by oil, diesel, gas and coal seam gas has been compiled. The list shows several thousand MWe of generation where statistics are readily available.

[vi] There are no official statistics of this topic. It is known, based on published sources, that BHP's Olympic Dam mine in South Australia maintains a diesel generation capability that exceeds 100 MWe.

[vii] These estimates vary widely. The variation derives from physical differences (age of the installation, distance from fuel and support depots); size and buying power of the owner; and accounting differences. Clearly, energy supply chain disruptions due to the Russian invasion of Ukraine have pushed fuel prices higher which would suggest that the numbers mentioned herein could be low.

[viii] Oil import information came from *Australia Petroleum Statistic*s, Dept of Industry, Science, Energy and Resources, Issues 300, July 2021, Australia. Domestic production data came from statistica.com. Volume equivalents came from various internet sources.

[ix] Statistica.com reports this value with a footnote that the precise level of strategic reserves is not a published number but rather one that is derived from consumption, production and import data.

[x] Data obtained from Caterpiller Tractor online shows diesel consumption to be 120 liters per 400 kwhr of electricity. Assuming the 3,000 MWe baseload generators operate for 8,000 hours per year, and the 1,500 MWe standby generators operate for 2,000 hours per year, then a total of 27 billion kwhr of electricity is generated using diesel generators. Using the fuel conversion above, the total annual consumption is 8 billion liters per year.

[xi] Burning 1 liter of diesel causes the release of 2.7 kg of CO2. Thus eliminating the consumption of 8 billion liters of diesel removes 22 million tonnes per year of emission. A figure of 400 million tonnes per year is used as the current release of CO2.

[xii] The deployment of 4,500 MWe of MMR generation would have a CAPEX of A$90 billion. It is assumed that one third of this is local content, thus a total spend in Australia of A$30 billion. At present, the total annual construction expenditure of A$360 billion supports the direct employment of 1.1 million workers. Thus the expenditure of A$30 billion would generate 92,000 person-years of direct employment.

[xiii] See *Economic Impact of the Pangea Project*, Access Economics, 1998.

[xiv] Using the CAT 3516 diesel generator as a model, the exhaust contains 2.6 g of NOX per cubic meter as well as 17.6 mg of PM2.5 and PM10 particulate. Determining the impact of these emissions would require very detailed transport and health impact modeling. However, the literature defends the conclusion that a material reduction in national release of NOX and PM will lower respiratory illness in Australia.

[xv] The cost of diesel generation is estimated to be US$0.30 per kwhr. For MMR generation, a price of US$0.15 is assumed. There are many variation factors in this, so "mid-point" estimates are used. The current total cost of diesel generation is A$10.8 billion per year.

[xvi] This is based on the sale of 20 million tonnes per year of carbon offsets for A$90.92. This is based on a current average EU price of €56. In the event that Australian-based nuclear generation does not qualify for EU sale, then the credits are likely tradeable in Australia subject to validation and verification.

[xvii] The average tax rate of ASX200 firms is 23%.

[xviii] 400,000 person-years at $150,000 annual income is A$60 billion in income. Income tax is estimated to be one third of this amount.

[xix] The deployment benefit is based on MMRs being deployed by Independent Power Producers which sell electricity to the consuming industries and communities.