14 February 2020

Nuclear Prohibition Inquiry
Parliament of Victoria
Parliament House
Spring Street
East Melbourne VIC 3002

Dear Committee Secretariat,

Please find enclosed a public submission from Women in Nuclear Australia Inc. (WiN Australia) on the inquiry into Nuclear Activities (Prohibitions) Act 1983 for your consideration. WiN Australia is available and willing to provide further evidence if required to the committee through hearings. The WiN Australia points of contact for any further information or clarification are:

President, Joanne Lackenby

Vice-President, Jasmin Diab

WiN Australia looks forward to the results of the inquiry and are postured to continue informing the debate through expertise and neutrality.

Sincerely,

Jasmin Diab
WiN Australia Vice-President
Submission to
Environment and Planning Committee, Legislative Council, Parliament of Victoria

Inquiry into Nuclear Prohibition in the Nuclear Activities (Prohibitions) Act 1983
Dated: 14 February 2020

Executive Summary

Women in Nuclear (WiN) Global is a not for profit association of women and individuals of other genders who work professionally in various fields of nuclear technology and radiological applications. WiN Australia Inc. is the Australian chapter of WiN Global. WiN Australia values its position as a professional organisation and seeks to inform this debate through expertise and neutrality rather than lobbying.

WiN Australia would welcome the opportunity to give evidence at a public hearing for this very important inquiry.

Due to the ever-increasing concern of climate change, nuclear energy should be considered to be part of Victoria’s energy mix to reduce carbon emissions. Nuclear energy also provides stable, reliable power and can be cost effective, especially when considering the lifespan of a nuclear plant. The ability to have an educated and robust discussion on nuclear power generation is restricted due to current federal and state legislation. Removing the ban on nuclear energy does not mean that nuclear facilities will be built overnight - it is the first step in allowing the consideration of an additional energy source.

WiN Australia makes the following key recommendations and comments:

a. That Victoria remove the prohibition against nuclear energy and consider nuclear energy as part of the mix due to its:
   - very low carbon intensity and demonstrated ability to decarbonise electricity sectors
   - low environmental impacts (low mining and land use requirements)
   - long asset lifetime
   - high capacity factor (operates continuously 24/7 for months or years between refueling)
- ability to provide energy abundance and hence maintain or even further improve the lifestyles of Victorians
- suitability in replacing many of Victoria’s aging fossil fuel plants and utilisation of the same infrastructure e.g. pole and wires, especially small modular reactors
- ability to provide alternate benefits, such as heat for industry or desalination

b. That Victoria remove the prohibition against exploration and mining of uranium and thorium. Significant opportunity may exist for Victoria to supply uranium to support climate change efforts in countries with nuclear power programs in the near to midterm, and thorium in the mid to long term.

c. Studies of deep decarbonisation, such as a Massachusetts Institute of Technology (MIT) study referenced in the submission, indicate that deep decarbonisation is most economical when nuclear and other renewables are used in combination. Many small modular reactors being built may be a more economically feasible option for Victoria rather than a couple of large reactors. The Committee should become familiar with the MIT study and the costs associated with deep decarbonisation.

d. That the Committee become familiar with the open source project, Electricity Map - www.electricitymap.org. If Victoria’s goal is to decarbonise its electricity sector, and potentially other sectors, then Electricity Map clearly indicates that the technologies that have demonstrated they can meet the challenge are hydropower and nuclear power.

e. Opportunities in uranium mining lie in the reskilling of current fossil fuel mining employees, particularly those employed in the coal industry. This will enable an already skilled workforce to have sustainable job security into the future.

f. The potential benefits of nuclear power are not only for Victoria’s and Australia’s national interest but also benefit the international community, in particular to women and children and those nations most affected by climate change across the globe.
Contents:

1. About Women in Nuclear
2. Why nuclear energy is feasible and suitable for Victoria
3. Response to terms of reference outlined to the Committee:
   a. The potential for Victoria to contribute to global low carbon dioxide energy production through enabling exploration and production of uranium and thorium;
   b. Identify economic, environmental and social benefits for Victoria, including those related to medicine, scientific research, exploration and mining;
   c. Identify opportunities for Victoria to participate in the nuclear fuel cycle; and
   d. Identify any barriers to participation, including limitations caused by federal or local laws and regulations.
4. Conclusion and recommendations
1. About Women in Nuclear

Women in Nuclear (WiN) Global is a not for profit association of women and individuals of other genders who work professionally in various fields of nuclear technology and radiological applications. WiN has over 35,000 members from 110 countries. One of the aims of WiN is to promote understanding and public awareness of the benefits of peaceful nuclear and radiological applications, including nuclear energy, especially amongst women and young people.

WiN Australia Inc. is the Australian chapter of WiN Global. Membership of WiN Australia includes individuals working professionally in many areas including research, nuclear operations, security, medicine and health care, waste management, regulatory authorities, mining, nuclear and radiation safety, industry, policy and communications. WiN Australia values its position as a professional organisation and seeks to inform this debate through expertise and neutrality rather than lobbying.

1.1 WiN’s Position on Nuclear Energy

The global WiN community sees nuclear energy technology as a key part of the solution in the fight against climate change. In 2015, WiN Global produced a document known as the “Women in Nuclear Declaration for the Earth Climate”. The document acknowledges:

- that the world’s population should reach 10 billion people and electricity demand should double by 2050, and
- that if the world is to limit global warming to a maximum of 2°C by 2050, over 80% of electricity will need to come from all available low carbon technologies

(Intergovernmental Panel on Climate Change, IPCC)

The Declaration calls for immediate steps to reduce carbon emissions that include nuclear energy as an option, as agreed by the IPCC, Organisation for Economic Co-operation and Development (OECD) and many other organisations.

WiN Australia also acknowledges the UN Sustainability Development Goals and understands that sustainable and reliable energy is a key part of meeting these goals. With around a billion people worldwide still without access to electricity, there is still much work to be done. As poverty, natural disasters, climate change and inequality inadvertently affect women and children the most, WiN Australia supports the move away from fossil fuel energy generation
towards sources that will improve the lives of the world’s poorest and those that will be most impacted by climate change.

**Recommendation 1:** Nuclear energy is a proven, low emissions technology. It is recommended that the Committee considers not only the potential benefits of nuclear power to Victoria’s and Australia’s national interest but also to the international community, in particular to women and children and those nations most affected by climate change across the globe.

2. **Why nuclear energy is feasible and suitable for Victoria**

Nuclear energy is an important part of the energy mix to meet Victoria’s growing need for reliable, affordable and clean power. Nuclear energy is a solution to the energy trilemma.

Nuclear energy offers the densest energy solution available and is technologically advanced. Small modular reactors and Generation IV reactors provide highly capable, scalable power solutions with an increased focus on accident resistance and a reduced threat to nuclear security. These reactors are able to service cities through to small remote towns with a reliable power supply on a reduced footprint in comparison to other energy forms, therefore allowing precious land to be salvaged for agriculture, industry, population growth or for wildlife and green areas.

Innovation is a key pillar within the nuclear industry. Nuclear energy offers significant opportunities to decarbonise not only the electricity sector but also the transport and fixed energy sectors. In the absence of significant hydropower, no other technology has so far demonstrated it can decarbonise electricity let alone other sectors.

Nuclear energy offers additional opportunities including the generation of heat for industry and desalination. If Victoria is to remain competitive in the manufacturing and technology spheres, we need energy abundance, not energy deficiency. Nuclear offers reliability and abundancy with low carbon emissions, unlike other technologies that are intermittent and often rely on fossil fuels for backup.
3. Response to Committee’s Terms of Reference

3.a. The potential for Victoria to contribute to global low carbon dioxide energy production through enabling exploration and production of uranium and thorium

Due to the prohibition of certain nuclear activities, Victoria has an unknown potential to contribute to a global low carbon dioxide energy production, namely nuclear power, through the provision of uranium and thorium. Figure 1 and 2 highlight the known mineral base for uranium and thorium provided by Geoscience Australia. At present, Australia’s uranium and thorium resources are for export however should the Federal government overturn the current prohibition on nuclear power, there could be an Australian uranium market in the future.

Figure 1 indicates there are no known viable uranium deposits in Victoria. Due to current state ban on nuclear activities, the ability to conduct exploration and survey of uranium mineral deposits has been heavily restricted.

Figure 1: Uranium deposits and mines in Australia (Geoscience Australia, 2017)
Figure 2 outlines the known thorium deposits within Victoria. These deposits are within the Murray Basin located with heavy mineral sand deposits. Therefore, there is a viable resource for Victoria to provide in support of thorium reactor technology. However, thorium reactor technology remains a challenge requiring significant research and development investment currently occurring in the United States and China (World Nuclear Association, 2017). Therefore, there is no significant demand for thorium in the short to medium term, and the exploration and mining of thorium may not be seen as economically viable for Victoria, at least in the short to medium term.

Figure 2: Thorium deposits and mines in Australia (Geoscience Australia, 2017)

According to the World Nuclear Association, there are over 100 power reactors currently on order or planned, and 300 more are proposed. Most of the planned reactors will be based in Asia where there are fast growing economies and rapid increases in electricity demand. About 50 power reactors are currently being constructed in 15 countries. In addition, many countries with existing nuclear programmes either have plans to, or are currently building, new plants.
About 30 countries are considering, planning or starting nuclear power programs (World Nuclear Association, 2020).

Nuclear expansion worldwide, but particularly in the Asian region, presents opportunities for Victoria to contribute to low emissions energy production through supply of uranium.

**Recommendation 2:** That Victoria remove the prohibition against exploration and mining of uranium and thorium. Significant opportunity may exist for Victoria to supply uranium to support climate change efforts in countries with nuclear power programs in the near to midterm, and thorium in the mid to long term.

3.b. Identify economic, environmental and social benefits for Victoria, including those related to medicine, scientific research, exploration and mining;

3.b.1. Nuclear Energy

**Economic opportunities associated with Nuclear Energy**

Nuclear energy is affordable and nuclear plants are valuable assets. Current operating nuclear power plants produce low-cost power and support stable electricity prices. Nuclear power plants are reliable and capable of operating 24/7 and are resilient to extreme weather events. The operation, maintenance and fuel costs at United States nuclear plants are approximately one-third cheaper than for fossil steam power generation ($24.4/MWh compared to $35.4/MWh) (World Nuclear Association, Talking Points, The nuclear industry communication handbook 2019). As well as reducing overall energy provision costs, nuclear power plants are valuable long-term assets with a lifespan of 60 years operations or longer. Therefore, while capital upfront costs are considered significant, the operational longevity of the power plants make them cost effective. In the European Union, the nuclear sector supports over 1 million jobs and generates 500 billion euros in economic impact (World Nuclear Association, Talking Points, The nuclear industry communication handbook 2019).

Reduction to capital costs can be made through building multiple units of the same design and following international best practice on tried and tested technology. Small Modular Reactors are
currently in the testing phase with a handful operating in Russia, China and India (World Nuclear Association, 2020). In time will provide tried and tested technology to complement the fleet of nuclear energy solutions. This allows for an established supply chain to reduce initial costs as well as the ongoing maintenance and supply through the lifetime of the reactor.

**Recommendation 3.** The committee acknowledge the nuclear industry performance across the United States and Europe and that nuclear plants provide long term valuable assets that over their operational lifetime produce reduced energy costs in comparison with fossil fuel power generation.

Industry Super Australia released a *Modernising Electricity Sectors* report that outlined cost comparisons for overall energy production. Overall cost for nuclear power plant generation is not just reliant on the physical plant itself, but also the supply chain required. Table 1 outlines the cost comparison of six different power generation facilities:

<table>
<thead>
<tr>
<th>Serial</th>
<th>Energy Generation type</th>
<th>Location</th>
<th>Cost / GW output</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Solar (photovoltaic)</td>
<td>Darlington point, NSW, Australia</td>
<td>$AU 5.8Bn</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Solar (Thermal)</td>
<td>Ivanpah System, California, USA</td>
<td>$US 21Bn</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Wind</td>
<td>Dundonnel, Victoria, Australia</td>
<td>$AU 4.2Bn</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Nuclear</td>
<td>Olkiluoto, Finland</td>
<td>$US 6-7Bn</td>
<td>Most expensive option</td>
</tr>
<tr>
<td>5</td>
<td>Nuclear</td>
<td>UAE</td>
<td>$US 4.5Bn</td>
<td>Average cost option</td>
</tr>
<tr>
<td>6</td>
<td>Nuclear</td>
<td>China (Generation IV reactor)</td>
<td>$US 1.8-2.6Bn</td>
<td>Cheapest cost option</td>
</tr>
</tbody>
</table>

As demonstrated above, small modular reactors and generation IV reactors, with their small footprint significantly reduce the overall cost for energy production. However, for these costs to
be realised, there needs to be a reliable and effective supply chain associated. China has been able to do this due to the large number of big and small reactors being built across the entire country.

A recent study from the Massachusetts Institute of Technology ("The Future of Nuclear Energy in a Carbon-Constrained World") highlighted the following main points:

1) In a deeply decarbonised grid, nuclear can prevent electricity cost escalations when deployed efficiently. Without that contribution, the cost of achieving deep decarbonisation targets increases significantly.

2) The cost of building new nuclear plants in the west in recent years has been high. There are ways to reduce the cost of new nuclear. Governments play a large role in helping to reduce costs.

An important aspect of this study is that when very low carbon emissions standards are set (in terms of gCO2/kWhe) the cost of renewables only systems increases dramatically due to the requirement to build huge capacities to maintain reliability. A combination of nuclear and renewables was therefore identified as the most affordable.

Recommendation 4. Evidence from the MIT study shows that deep decarbonisation is most economical when nuclear and other renewables are used in combination. Many small modular reactors being built may be a more economically feasible option for Victoria rather than a couple of large reactors. The Committee should become familiar with the MIT study and the costs associated with deep decarbonisation.

Social opportunities associated with Nuclear Energy

Due to current legislation, in particular bans on nuclear energy at the federal and state levels, it is difficult to have an informed discussion with the community on nuclear energy. Demand for reducing carbon emissions and taking action on climate change exist across the Victorian population. Therefore, it is appropriate that we allow for nuclear to be included in the discussion on reducing carbon emissions.

The nuclear industry is committed to improving public outreach. Lack of effective communication in the early stages of the nuclear industry left gaps that were filled by persistent myths. In
countries where nuclear power plants operate, there is good public support (*World Nuclear Association*, Talking Points, The nuclear industry communication handbook 2019).

Organisations like Women in Nuclear (WiN) Global were established for community engagement. Originally, WiN was established to provide women in communities with information and education around nuclear power providing safe, cheap and reliable energy to families.

Due to current legislation, it is difficult to have an educated discussion with the community on nuclear energy. The demands for reducing carbon emissions and taking action on climate change are there from a wide Australian community. Therefore, it is appropriate that we allow for nuclear to be included in the discussion on reducing carbon emissions.

**Recommendation 5:** In order to allow for informed community engagement and public debate, current legislation regarding nuclear power should be updated to allow nuclear power to be considered as part of the energy mix for reducing Victoria’s carbon emissions.

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**Environmental opportunities associated with Nuclear Energy**

**Summary**

Nuclear energy has a small environmental footprint. Electricity generation in Australia accounts for approximately one third of the country’s greenhouse gas emissions. Of this, residential electricity accounts for about one third, i.e. one ninth of total emissions. In 2014, the IPCC analysed hundreds of scientific papers examining the carbon dioxide equivalency (in gCO$_2$/kWh) of different energy sources (IPCC Working Group III – Mitigation of Climate Change, Annex III, Table A.III.2), with the results shown in Table 2.

**Table 2:** Carbon dioxide equivalency of common sources of electrical generation

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Lifecycle Emissions Median Value gCO$_2$/kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>820</td>
</tr>
<tr>
<td>Gas - combined cycle</td>
<td>490</td>
</tr>
<tr>
<td>Hydropower</td>
<td>24</td>
</tr>
<tr>
<td>Concentrated solar</td>
<td>27</td>
</tr>
<tr>
<td>Solar PV – rooftop</td>
<td>41</td>
</tr>
<tr>
<td>Solar PV – utility</td>
<td>48</td>
</tr>
<tr>
<td>Wind onshore</td>
<td>11</td>
</tr>
<tr>
<td>Wind offshore</td>
<td>12</td>
</tr>
<tr>
<td>Nuclear</td>
<td>12</td>
</tr>
</tbody>
</table>
Nuclear energy offers an opportunity to greatly reduce emissions from not only electricity generation, but also from the transportation and fixed energy sectors. Nuclear energy requires much less land use than other forms of low emissions electricity generation. Compared to fossil fuels, nuclear energy requires significantly less fuel. Compared to all other forms of energy, nuclear requires less mining, transport and material consumption. Furthermore, nuclear energy manages 100% of its waste, which can be efficiently stored and largely recycled.

The freshwater usage requirements of a nuclear plant are slightly larger than a conventional fossil fuel plant, but not large enough to discount nuclear energy due to this factor alone. While large amounts of water are used for cooling, 99% of this water is returned to the environment, only a few degrees warmer and free of contaminants as the cooling water is circulated through heat exchanges and is never exposed to radioactive material.

It is acknowledged that no form of energy generation is perfect from an environmental standpoint. Although there are some environmental impacts associated with nuclear energy, they are either of an equivalent magnitude or substantially reduced when compared to other forms of energy generation.

**Greenhouse gas emissions**

Nuclear energy offers an opportunity to greatly reduce greenhouse gas emissions across the electricity generation, transportation and fixed energy sectors. Nuclear fission does not produce any carbon dioxide or other greenhouse gases. The emissions from other parts of the fuel cycle (e.g. mining of uranium and enrichment of uranium) are less than 2% of those from using coal for electricity generation (“Nuclear Energy in the 21st Century”, Ian Hore-Lacy).

The open source project, Electricity Map - [http://www.electricitymap.org](http://www.electricitymap.org) - provides live data on carbon emissions for many parts of the world based on how the electricity is being generated, including Victoria. Data is drawn from publicly available sources, published by electricity grid operators, official agencies and others. Greenhouse gas emissions are then calculated for each electricity source based on emissions intensities derived by the IPCC (Table 2), and the live carbon intensity in gCO$_2$eq/kWh displayed. The data from Electricity Map is clear – areas with very low emissions either have abundant hydropower resources (e.g. Tasmania, Norway, Sweden) and/or significant nuclear resources (e.g. France, Sweden, Ontario). Areas with significant ‘renewables’ installed, such as wind and solar, whilst having lower carbon emission
than those areas relying mostly on fossil fuels, can swing wildly in their emissions due to the intermittency of these technologies and the reliance on fossil fuel backup (e.g. Germany, South Australia, California). If the world is to achieve deep decarbonisation, i.e. at least an 80% drop in carbon emissions to remain within the 2°C scenario, then large scale adoption of stable, reliable, high capacity factor sources of electricity generation, such as hydro and nuclear, are needed. Australia is not fortunate to have abundant hydro resources, hence nuclear appears to be the next best option if the goal is very low carbon emissions.

At 1756h AEDT on 13 January 2020, Victoria was producing 613g carbon intensity (gCO₂eq/kWh) with only 21% of power produced from low-carbon (hydro) and 21% by renewables (wind and solar). The world target for the 2050 2°C scenario is in the order of 10 to 25 g/kWhe for the electricity sector (MIT – “The Future of Nuclear Energy in a Carbon-Constrained World”). Therefore, there are many more opportunities for Victoria to improve its carbon emissions through an increase of low-carbon energies. (electricitymap.org)

**Land footprint**

One of the significant benefits of nuclear energy is that it requires less land than every other form of electricity generation. For example, a solar farm requires 450 times more land to produce the same amount of energy as a nuclear power plant (“Why renewables can’t save the planet”, Michael Shellenberger, Quillette, Feb 27, 2019). An important aspect of preventing climate change will be returning as much land as possible back to its ‘wild state’ i.e. a lot of trees and wildlife. Nuclear energy is particularly well suited to this because of its high energy density and small land usage requirements.

**Water use**

One criticism that is often quoted about nuclear energy is that it uses a lot of water. The freshwater usage requirements of a nuclear plant are slightly larger than that of a conventional fossil fuel plant but are not large enough to discount nuclear energy due to this factor alone. In addition, due to the small amounts of fuel used for nuclear energy compared to gas or coal, there is greater flexibility in the location of nuclear reactors. Hence reactors on the coast could desalinate water to cool themselves (or provide drinking water to communities) whilst at the same time generating electricity.

**Mining magnitude**

According to “Metals for a low-carbon society”, Olivier Vidal, Bruno Goffé & Nicholas Arndt, Nature Geoscience volume 6, pages 894–896 (2013), for an equivalent energy output,
“solar and wind facilities require up to 15 times more concrete, 90 times more aluminium, and 50 times more iron, copper and glass than fossil fuels or nuclear energy”.

The sheer quantity of mining required to build nuclear and fossil fuel facilities is therefore significantly smaller than renewable technologies for the materials mentioned. Plus the amount of mining required for fuel for nuclear energy compared to fossil fuel generation is substantially less. The environmental consequences from mining for nuclear energy, therefore, are substantially less than other forms of energy generation.

**Recommendation 6:** That the Committee become familiar with the open source project, Electricity Map - [www.electricitymap.org](http://www.electricitymap.org). If Victoria’s goal is to decarbonise its electricity sector, and potentially other sectors, then Electricity Map clearly indicates that the technologies that have demonstrated they can meet the challenge are hydropower and nuclear power.

**Recommendation 7:** That the Committee acknowledge that due to nuclear energy’s low mining, resource and land use requirements, high energy density and extremely low greenhouse gas emissions, nuclear energy is a feasible and suitable technology for Victoria in terms of its low environmental impacts.

### 3.b.2. Exploration and Mining

**Environmental opportunities associated with Exploration and Mining**

Due to the immense energy density of uranium, the amount of uranium needed for energy generation is a tiny fraction of the amount of mining required for fossil fuels. Australia has the world’s largest known reserves of uranium, predominately in South Australia, Western Australia, the Northern Territory and Queensland. While Victoria is not known to have significant uranium reserves, however its potential for this resource is unknown as current state legislation prohibits uranium exploration and mining. Australia is well placed to provide a reliable source of fuel for reactors if Victoria chooses to pursue nuclear energy. The environmental impact of uranium mining is not significantly different to the environmental impact of mining other heavy metals, such as rare earths and other elements used in solar panels or wind turbines, both produce toxic tailings, whether chemically or radioactively toxic.

Refer also to section 3.b.1 Mining Quantity.
Australia’s largest uranium mine, Olympic Dam, is in fact a copper mine. It is also a gold mine, and a silver mine. It makes sense from an environmental and sustainability viewpoint that if you’re going to dig up the ground, extraction of all available minerals should be undertaken. The same principle applies equally in Victoria.

**Economic and social opportunities associated with Exploration and Mining**

Uranium mining activities can contribute greatly to local and national government revenues through royalties, taxes and foreign exchange benefits. Uranium mining can also foster improvements in social conditions both in local communities and further afield including direct creation of employment with the resulting income and wealth accumulation. Uranium mining has the potential to provide additional benefits to stakeholders through investment in social services such as health and education in mining regions. Pre-job training and transferable skills provide opportunities beyond the mine. Construction of infrastructure including roads and railways as well as operation of the uranium mine can provide direct and indirect benefits as well as economic stimulus into regional areas. This has the potential to increase or sustain regional employment and facilitate indirect employment through the lifetime of the uranium mine as part of its supply chain. Uranium companies globally have invested in the past in community infrastructure in local impact communities, as part of local or national government lease agreements or as part of the mine company’s corporate social responsibility strategy.

Mining may also have a positive impact on environment e.g. rehabilitation of previously disturbed land, monitoring of environmental conditions.

**Recommendation 8:** Opportunities in uranium mining lie in the reskilling of current fossil fuel mining employees, particularly those employed in the coal industry. This will enable an already skilled workforce to have sustainable job security into the future.

**3.b.3. Health and safety**

**Social Opportunities associated with Nuclear Technology**

The World Health Organization estimates that at least 7 million people die annually from air pollution, and that 9 out of 10 people breathe air containing high levels of pollutants
Nuclear energy can play a major role in reducing these statistics.

*Electricity generation and health* (2007) by Markandya and Wilkinson outlined that nuclear energy causes the lowest number of fatalities of any major electricity source, over 100 times less than coal and natural gas. There are unfortunately many myths around death tolls from nuclear accidents associated with nuclear energy. Due to these myths and the scrutiny of safety and accidents in the nuclear industry, the global nuclear industry has a strong safety culture through the World Association of Nuclear Operators (WANO) where best practice in safety is shared and exchanged globally.

Nuclear accidents are very rare. The World Health Organization determined that the major impacts of Chernobyl and Fukushima were not caused by radiation exposure but were due to psychological and socio-economic factors resulting from misconceptions and fears about radiation.

**Recommendation 9: Health and safety needs to be included for consideration when discussing Victoria’s energy mix.** As a very low emissions technology with advanced safety management, the types of nuclear reactors under construction in the world today align with Australia’s high standards and expectations for health and safety.

Education, as well as demystifying myths and propaganda surrounding uranium mining and nuclear energy, are key. This allows for the community to be involved in an educated discussion on the advantages and disadvantages of nuclear technology, and also other energy technologies. It will help to remove emotion from the argument. Engaging the nuclear community to support this communication and education strategy will allow for this information to be disseminated. The first milestone is including nuclear energy as a part of the clean and sustainable energy debate.

Addressing the common concerns of environmental and health impacts of uranium mining should be part of the education process. The Organization for Economic Co-Operation and Development (OECD) Nuclear Energy Agency publication 2014 publication “Managing Environmental and Health Impacts of Uranium Mining” (Reference OECD 2014 NEA Publication).
No 7062) would be a useful document to reference. The report provides a factual account of leading practices in order to inform public debate on uranium mine development and to provide policy makers with a framework of approaches that should be undertaken to ensure that uranium mining is conducted in a safe and environmentally responsible manner.

The report indicates that “key components in achieving this goal [of uranium mining in a safe and environmentally responsible manner] include the establishment of an appropriate regulatory framework, planning for closure before the mine begins production, requiring financial assurance from companies to cover the costs of closure and remediation, application of leading practices to minimise radiation exposure of workers and the public, protection of water resources and the safe, long-term disposal of tailings and problematic waste rock. Public consultation and information sharing, environmental impact assessment and environmental monitoring throughout the life cycle of the mine facility are also shown to be crucial components of this framework.”

**Recommendation 10:** In order to allow the Victorian population to have a complete, informed and robust discussion on the viability of uranium mining and nuclear power generation in Victoria, education and two-way communication is vital.

3.b.4. Scientific Research and Development

**Social and economic opportunities**

Victoria already hosts The Australian Synchrotron, a branch of the Australian Nuclear Science and Technology Organisation (ANSTO), which provides advanced techniques to support research in many areas including health, energy, mining and agriculture (ansto.gov.au). Both the Australian National University (ANU) and University of New South Wales (UNSW) offer masters level nuclear courses, nuclear physics and nuclear engineering respectively, therefore already providing technical skills and knowledge into the current Australian workforce. The expansion of these courses to form undergraduate nuclear engineering programs could increase and develop a skilled workforce within Australia. Therefore, there are opportunities for Victorian universities to collaborate in research and development in the fields of electronics and electrical engineering in the realm of power and energy systems, fuel technologies, safety, security and safeguards.
Recommendation 11. Victorian-based tertiary institutions should be involved in nuclear research and development.

3.c. Identify opportunities for Victoria to participate in the nuclear fuel cycle

3.c.1 Support to entire Nuclear Fuel Cycle – regulation

Victoria could provide support to regulation through the following opportunities:

- **Uranium mining** – Current mine site regulation and licensing through the Victorian Government Department – Earth Resources – would be adequate. Safeguards regulations surrounding the processing and transport of uranium resources would need to be managed in accordance with current federal legislation overseen by the Australian Safeguards and Non-Proliferation Office (ASNO).

- **Nuclear power generation** – The ARPANS Act currently prohibits the building of nuclear power plants in Australia. However, it could readily be modified and expanded to include the necessary conditions to allow and regulate nuclear power. A single national regulatory body for nuclear safety and radiation protection would provide an avenue for reactor safety practices, polices and innovation to be shared openly and honestly across the sector within Australia as well as linking with regional and international partners to share best practice for nuclear power reactors.

- **Nuclear waste disposal** – The Australian Government has established the National Radioactive Waste Management Facility (NRWMF) project (industry.gov.au/strategies-for-the-future/managing-radioactive-waste) which will outline requirements for a national waste facility. A site has recently been announced for the facility in Kimba, South Australia. Should Victoria plan a nuclear energy program, it would need to work with the federal government or adopt its own waste disposal facility.

Recommendation 12: The global nuclear industry is subject to one of the most stringent regulatory regimes of any industry. In the case that Victoria embarks on a nuclear power regime and commences mining uranium, a sensible combination of state and national regulation/legislation could be implemented.
3.c.2. Mining and milling

As discussed in part 3.a., there is unknown potential for Victoria’s opportunities in mining and milling of nuclear fuel materials, namely uranium and thorium. In the instance that significant reserves of uranium are discovered in Victoria, an opportunity may exist for the state to supply uranium to support climate change efforts in countries with nuclear programs.

**Recommendation 13:** Remove the prohibition against the exploration and mining of uranium to allow Victoria to understand what uranium mineral deposits are within the state to support global nuclear power technologies. We also recommend this prohibition is removed to enable Victoria to better understand the potential thorium resources available for long-term export.

3.c.3. Processing, enrichment and fuel fabrication

Until Australian federal legislation prohibiting nuclear activities is removed, it is illegal for any entity in Australia to process uranium, enrich uranium and develop nuclear fuel assemblies. Should this ban be removed, and Australia utilises nuclear energy as part of its national energy network, there will be a requirement for nuclear fuel specific to the reactors adopted for use in Australia. Opportunity exists for Victoria to be involved in establishing fuel processing and fabrication facilities. Consideration for enrichment activities as well as nuclear fuel processing would need to account for International Atomic Energy Agency requirements and Australian treaty commitments (e.g. Non-proliferation Treaty), as well as approvals and licensing from Australian regulatory bodies, namely ASNO and ARPANSA. This has the potential for an entire new industry for the state of Victoria which could support national and international nuclear fuel requirements.

**Recommendation 14:** If the Australian federal legislation prohibiting nuclear activities is removed, Victoria should explore its options to support a nuclear fuel industry.
3.c.4. Nuclear reactor use

Nuclear energy provides sustainable and reliable power that can work alongside other low carbon technologies. Not all areas in Victoria will be viable locations for nuclear power generation. Therefore, the energy mix needs to consider other zero and low carbon emission energy sources suitable per location, including hydro, solar and wind, if the objective is deep decarbonisation. Each of these technologies come with their own challenges in regard to waste, power production, land usage, intermittency and power storage requirements. Nuclear power supports and produces sustainable and reliable power through use of advanced reactor technologies.

Small Modular Reactors (SMR) increase the flexibility of nuclear energy therefore allowing nuclear power to be used in more locations and for a greater range of purposes, for example in remote townships and providing offshore humanitarian assistance. There are approximately 50 SMR designs and concepts globally in various development stages, some nearing operational use. Nuclear reactors, especially SMRs, would be a suitable replacement for many of Victoria’s aging fossil fuel plants as they can be constructed to produce a similar energy output to the fossil fuel plants they would replace and can utilise the same infrastructure, e.g. poles and wires.

Advanced reactors like high temperature and fast reactors increase the efficiency of nuclear energy, therefore reducing waste. Fast reactors could increase the available fuel resource by about 60 times according to the World Nuclear Association. This means today’s used fuel could be reused, resulting in 60 times more energy than using the fuel just once. Fast reactors are already in operation including the Russian BN-800 which is used to dispose of weapons grade plutonium through its use as a fuel, reducing global proliferation risks.

Advanced Technological Fuels (ATF) allow for materials technology to produce fuel types that reduce waste but more importantly are able to stabilise and slow down reactions in the event of a nuclear accident. These advancements in fuel technologies will allow for reactors already operational to utilise fuels that improve safety and security standards.
**Recommendation 15.** Any discussion on Victoria pursuing use of nuclear energy as part of a wider energy mix should consider the advancement in nuclear energy reactor designs and fuel designs in order to ensure Victoria is armed with the most up to date technology and avoids making decisions based on 1960’s-1980’s reactor technology.

**Recommendation 16.** Nuclear reactors, especially SMRs, would be a suitable replacement for many of Victoria’s aging fossil fuel plants as they can be constructed to produce a similar energy output to the fossil fuel plants they would replace and can utilise the same infrastructure, e.g. poles and wires.

### 3.c.5. Reprocessing and Waste Management

The volume of waste generated from nuclear energy is significantly less than the volumes generated from other forms of energy. Used fuel assemblies are over 95% recyclable, which also greatly reduces the lifetime of the waste. Victoria has the land mass, as well as the geotechnical and hydrological conditions necessary for long term safe and secure storage and disposal of radioactive wastes. Radioactive wastes are a small price to pay compared to the imminent and potentially devastating effects of climate change.

Unlike other toxic wastes, the principle hazard associated with nuclear waste is radioactivity, which diminishes over time. Used nuclear fuel loses 99.9% of its radioactivity in the first 40 years, making it easier to handle and manage ("Nuclear Energy in the 21st Century", Ian Hore-Lacy). Storage underwater and in dry casks is common international practice. Sweden and Finland (both of whom have chosen an “open fuel cycle”, i.e. do not reprocess/recycle their used fuel but instead to use it only once then dispose) are building deep underground facilities to dispose of their waste. Perceptions that there is no effective solution to manage radioactive waste are incorrect. There are a number of countries with well-established policies for waste disposal. Used fuel can also be seen as a valuable resource as the uranium, plutonium and, in future, minor actinides, can be recycled and reused in nuclear fuel.

Reprocessing of used nuclear fuel is the Australian government’s current approach to managing the used fuel that has and will arise from the country’s three research reactors (HIFAR, MOATA and OPAL). Should Victoria decide to develop nuclear energy technology, WiN Australia
encourages reprocessing of used nuclear fuel due to the benefits reprocessing bring in terms of recycling and sustainability, waste volumes and waste lifespan.

Transportation of used nuclear fuel and vitrified waste (the waste after reprocessing of used fuel) is a common practice around the world and has been done in Australia on many occasions to date without incident. Unlike many other dangerous goods that are transported by sea, rail or road as a liquid or gas, used nuclear fuel and waste is transported as a solid material in purpose-built casks that are designed for extreme conditions. Australia has the expertise and knowledge to transport these materials reliably and securely.

**Recommendation 17**: Victoria should consider adopting existing solutions for nuclear waste management which are sophisticated and effective. The Committee should consider the relatively small risks associated with radioactive waste management, transportation and storage arising from nuclear power technology, compared to the imminent and potentially devastating effects of climate change.

3.d. **Identify any barriers to participation, including limitations caused by federal or local laws and regulations.**

3.d.1. **Public opinion and gender participation**

The most recent poll on nuclear energy in Australia (to the author’s knowledge) resulted in a 51% support, 34% oppose, outcome ([Roy Morgan poll September 2019](https://www.roymorgan.com/radioactive-waste-public-opinion)). Nuclear energy, like many other forms of energy, will likely never have 100% support in Australia. However, given the opportunity, such as through the removal of the federal and Victorian state nuclear energy ban, the benefits of nuclear energy could become widely disseminated. Through also addressing myths and incorrect popular culture perceptions, support for nuclear energy as a powerful, reliable, safe, secure and low emissions technology could be intensified.

Roy Morgan’s September 2019 poll indicated an increase in the support for Australia to develop nuclear power to reduce Australia’s CO₂ emissions. Although not broken down by state, a
majority of 69% of Australians support the refining and exporting of radioactive materials mined in Australia for use in the health services industry compared to only 12% who do not.

While the majority in support of nuclear power is very slim, this survey identified that support for nuclear power was 65% male versus 38% female. This gender split was consistent across the survey. One of the key aspects of this poll that needs consideration is the percentage of women that indicated they “can’t say” (i.e. aren’t sure) was much higher for women than for men at 22% compared to 7%. There is therefore significant opportunity to gain further support from women.

The lack of engagement by women in the nuclear debate is considerable noting that female participation in climate change debate globally is quite high. The topic of nuclear energy can be polarising due to myths and misinformation. This topic is also affected by the widespread and unsubstantiated belief that renewables, entirely on their own, are capable of deep decarbonisation at the lowest cost. For this reason, it is important that the community, and women especially, are given access to reliable, factful information about all low carbon technologies. This will enable informed discussions on the key issues of concern when it comes to nuclear energy.

Community consultative committees with the inclusion of organisations like WiN Australia can provide a good community engagement forum for issues to be presented and debated.

**Recommendation 18:** Victoria recognise that its residents want affordable, reliable, low emissions electricity into the future, and nuclear energy can fulfill this. Education campaigns should be used to address the gaps amongst the general public in both understanding of nuclear energy and understanding of how deep decarbonisation could be achieved.

**Recommendation 19:** Ongoing, persistent, technically sound and empathetic communication with communities, and Victoria as a whole, is the best method to engage the community.

**Recommendation 20:** Any nuclear communications strategy for Victoria should prioritise engaging with the female population.
3. d. 2. Federal and State legislation:
The overarching current restriction to nuclear power generation in Victoria is the federal and state prohibitions on nuclear power generation. Should this legislation be changed, the key to establishing a viable nuclear power industry will be through the establishment of a workforce.

A nuclear power plant program would require a large skilled workforce and hence would introduce a new sector with a substantial number of well-paying jobs and growth. There is already nuclear capability in Australia in the form of government organisations, such as the Australian Nuclear Science and Technology Organisation (ANSTO), Australian Safeguards and Non-proliferation Office (ASNO). Moreover, the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) provides the backbone to establish a stand-alone nuclear regulatory body. These bodies are largely nationally focused, therefore, opportunity exists to establish state regulatory bodies and organisations for the safe, secure and peaceful use of nuclear power generation. Alternatively, Victoria could fall under a national system of regulation for nuclear power generation, which is common practice worldwide.

Nuclear expertise could be scaled up commensurate with the magnitude of the program. In addition, international expertise could also be utilised in the initial years until domestic expertise is appropriately established.

Victoria already has broad experience in large construction and infrastructure projects to provide support and skills to be used in nuclear power plant construction and could draw on this workforce. Nuclear energy would be particularly viable economically if there were incentives in place for low carbon technologies.

**Recommendation 21**: Adoption of nuclear energy is a suitable option for Victoria’s future that would generate jobs and growth. In the event that the state adopts nuclear energy, we recommend Victoria utilises and expands its existing expertise in nuclear technologies and large construction programs.
3.d.3. Community understanding on decarbonisation

Many countries throughout the world are setting the goal to be net carbon neutral by 2050. If Australia also chooses this target, community consultation can help to establish the path Australia takes to achieve the target. There appears to be a lack of understanding amongst the general public as to the magnitude of change required to achieve deep decarbonisation. For example, a solar panel on the roof of a house may lower electricity prices for the homeowner but will do little to help deep decarbonisation of industry, transport, fixed energy and agriculture - every other sector other than residential electricity use. Residential electricity use contributes approximately one-ninth of Australia’s carbon emissions. The community needs a better understanding in general of energy generation and energy markets to be able to grasp how nuclear energy and uranium mining could substantially help Australia achieve a net neutrality goal. The report by MIT mentioned earlier (“The Future of Nuclear Energy in a Carbon-Constrained World”), provides data on how costs are related to renewables penetration and carbon emission intensity. It shows that a combination of nuclear and renewables is the cheapest method of achieving deep decarbonisation. There seems to be a common public perception that renewables on their own would be the cheapest.

Recommendation 22: The general population in Victoria, as well as Australia, would benefit from increased exposure to energy production, supply and demand, and how various sectors such as electricity, transport, fixed energy and agriculture, contribute to greenhouse gas emissions. This would enable more meaningful discussions on nuclear energy and uranium mining.

4. Conclusion and Recommendations

Due to the ever-increasing concern of climate change, nuclear energy should be considered to be part of Victoria’s energy mix to reduce carbon emissions and ensure ongoing reliability of energy supply. WiN Australia is committed to providing technical and honest feedback to the community in regard to nuclear related issues. The ability to have an educated and robust discussion on nuclear power generation is restricted due to current federal and state legislation.

The following recommendations are made for consideration by the committee:
Recommendation 1: Nuclear energy is a proven, low emissions technology. It is recommended that the Committee considers not only the potential benefits of nuclear power to Victoria’s and Australia’s national interest but also to the international community, in particular to women and children and those nations most affected by climate change across the globe.

Recommendation 2: That Victoria remove the prohibition against exploration and mining of uranium and thorium. Significant opportunity may exist for Victoria to supply uranium to support climate change efforts in countries with nuclear power programs in the near to midterm, and thorium in the mid to long term.

Recommendation 3: The committee acknowledge the nuclear industry performance across the United States and Europe and that nuclear plants provide long term valuable assets that over their operational lifetime produce reduced energy costs in comparison with fossil fuel power generation.

Recommendation 4: Evidence from the MIT study shows that deep decarbonisation is most economical when nuclear and other renewables are used in combination. Many small modular reactors being built may be a more economically feasible option for Victoria rather than a couple of large reactors. The Committee should become familiar with the MIT study and the costs associated with deep decarbonisation.

Recommendation 5: In order to allow for informed community engagement and public debate, current legislation regarding nuclear power should be updated to allow nuclear power to be considered as part of the energy mix for reducing Victoria’s carbon emissions.

Recommendation 6: That the Committee become familiar with the open source project, Electricity Map - www.electricitymap.org. If Victoria’s goal is to decarbonise its electricity sector, and potentially other sectors, then Electricity Map clearly indicates that the technologies that have demonstrated they can meet the challenge are hydropower and nuclear power.

Recommendation 7: That the Committee acknowledge that due to nuclear energy’s low mining, resource and land use requirements, high energy density and extremely low greenhouse gas
emissions, nuclear energy is a feasible and suitable technology for Victoria in terms of its low environmental impacts.

Recommendation 8: Opportunities in uranium mining lie in the reskilling of current fossil fuel mining employees, particularly those employed in the coal industry. This will enable an already skilled workforce to have sustainable job security into the future.

Recommendation 9: Health and safety needs to be included for consideration when discussing Victoria’s energy mix. As a very low emissions technology with advanced safety management, the types of nuclear reactors under construction in the world today align with Australia's high standards and expectations for health and safety.

Recommendation 10: In order to allow the Victorian population to have a complete, informed and robust discussion on the viability of uranium mining and nuclear power generation in Victoria, education and two-way communication is vital.

Recommendation 11: Victorian-based tertiary institutions should be involved in nuclear research and development.

Recommendation 12: The global nuclear industry is subject to one of the most stringent regulatory regimes of any industry. In the case that Victoria embarks on a nuclear power regime and commences mining uranium, a sensible combination of state and national regulation/legislation should be implemented.

Recommendation 13: Remove the prohibition against the exploration and mining of uranium to allow Victoria to understand what uranium mineral deposits are within the state to support global nuclear power technologies. We also recommend this prohibition is removed to enable Victoria to better understand the potential thorium resources available for long-term export.

Recommendation 14: If the Australian federal legislation prohibiting nuclear activities is removed, Victoria should explore its options to support a nuclear fuel industry.
Recommendation 15: Any discussion on Victoria pursuing use of nuclear energy as part of a wider energy mix should consider the advancement in nuclear energy reactor designs and fuel designs in order to ensure Victoria is armed with the most up to date technology and avoids making decisions based on 1960’s-1980’s reactor technology.

Recommendation 16: Nuclear reactors, especially SMRs, would be a suitable replacement for many of Victoria’s aging fossil fuel plants as they can be constructed to produce a similar energy output to the fossil fuel plants they would replace and can utilise the same infrastructure, e.g. poles and wires.

Recommendation 17: Victoria should consider adopting existing solutions for nuclear waste management which are sophisticated and effective. The Committee should consider the relatively small risks associated with radioactive waste management, transportation and storage arising from nuclear power technology, compared to the imminent and potentially devastating effects of climate change.

Recommendation 18: Victoria recognise that its residents want affordable, reliable, low emissions electricity into the future, and nuclear energy can fulfill this. Education campaigns should be used to address the gaps amongst the general public in both understanding of nuclear energy and understanding of how deep decarbonisation could be achieved.

Recommendation 19: Ongoing, persistent, technically sound and empathetic communication with communities, and Victoria as a whole, is the best method to engage the community.

Recommendation 20: Any nuclear communications strategy for Victoria should prioritise engaging with the female population.

Recommendation 21: Adoption of nuclear energy is a suitable option for Victoria’s future that would generate jobs and growth. In the event that the state adopts nuclear energy, we recommend Victoria utilises and expands its existing expertise in nuclear technologies and large construction programs.
Recommendation 22: The general population in Victoria, as well as Australia, would benefit from increased exposure to energy production, supply and demand, and how various sectors such as electricity, transport, fixed energy and agriculture, contribute to greenhouse gas emissions. This would enable more meaningful discussions on nuclear energy and uranium mining.

WiN Australia thanks the committee for considering the submission into the Nuclear Activities (Prohibitions) Act 1983.