Dear Standing Committee on Environment and Planning

Please accept my submission to the Victorian Parliament's Standing Committee on Environment and Planning 'Inquiry into Nuclear Prohibition'.

The aim of my submission to make the case for the current state prohibition on nuclear energy technologies and uranium exploration and mining to be lifted. It is my belief that no technology should be prohibited on simply ideological or political grounds. Nor should any technology be prohibited on economic grounds, as some submissions to this inquiry will argue. Nuclear energy should be no exception to these basic principles.

Added to this, with increasing pressure on policymakers to respond to climate change and Australia and Victoria's deepening energy woes, there is a need find and utilise alternative sources of energy that are clean, reliable and affordable. Nuclear energy is one source that must be part of this energy consideration, alongside other established and developing technologies. To date, Australian policymakers remain restricted to limited and inadequate solutions because of prohibitions at both the federal and state level regarding nuclear energy technologies, as well as moratoriums on gas exploration and extraction.

Therefore, the central role of this committee should be to differentiate the myths and the facts regarding nuclear energy and its associated mining activities. It should be informed by the best available science and real-world experience regarding the nuclear life cycle. And it should acknowledge that it is no longer appropriate to continue to make decisions in 2020 based of legislation passed in the 1980s, reflecting the views of the 1970s.

As such, my submission will address the inquiry's terms of reference by concentrating on the following key messages:

1. Australia is already an established nuclear nation with experience in managing and operating nuclear technology, undertaking nuclear research and is embedded in the nuclear fuel cycle.
2. Empirical evidence remains at odds with public perceptions and opposition arguments to nuclear energy based on health, safety, environmental impacts and economic feasibility.
3. With the need to act on climate change and growing concerns around energy reliability and affordability, Australians' aversion to nuclear power appears to be gradually waning.
4. The prohibition on nuclear energy in Australia at both the federal and state level remains the main inhibitor to further assessments regarding feasibility and development by both government and the private sector.

Please find enclosed with this letter my submission to the committee.

Yours sincerely,

Tristan Prasser
Ascot Vale, Victoria

1. A nuclear nation:

Australia is an established nuclear nation. Since the 1950s, Australia has had a long and positive relationship with civilian nuclear technology and research.

- **Research:** Australia has operated three research reactors in the Sydney suburb of Lucas Heights, with the OPAL reactor being the latest iteration. This facility produces life-saving isotope medicine and enables a plethora of important scientific research.[1]

- **Innovation:** Australia has developed its own solution to managing radioactive waste – Synroc[2] – which encapsulates waste in hot pressed rock matrices that will resist weathering for millennia.

- **Scientific expertise:** Australia's regulatory bodies such as Australian Nuclear Science and Technology Organisation (ANSTO) and Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) engage with the international community to ensure high standards of protection, security and operational best practice are maintained. Australia is also a participant in the Gen IV International Forum[3] - an international collaborative effort made up of 12 countries to develop the next generation of nuclear energy systems.

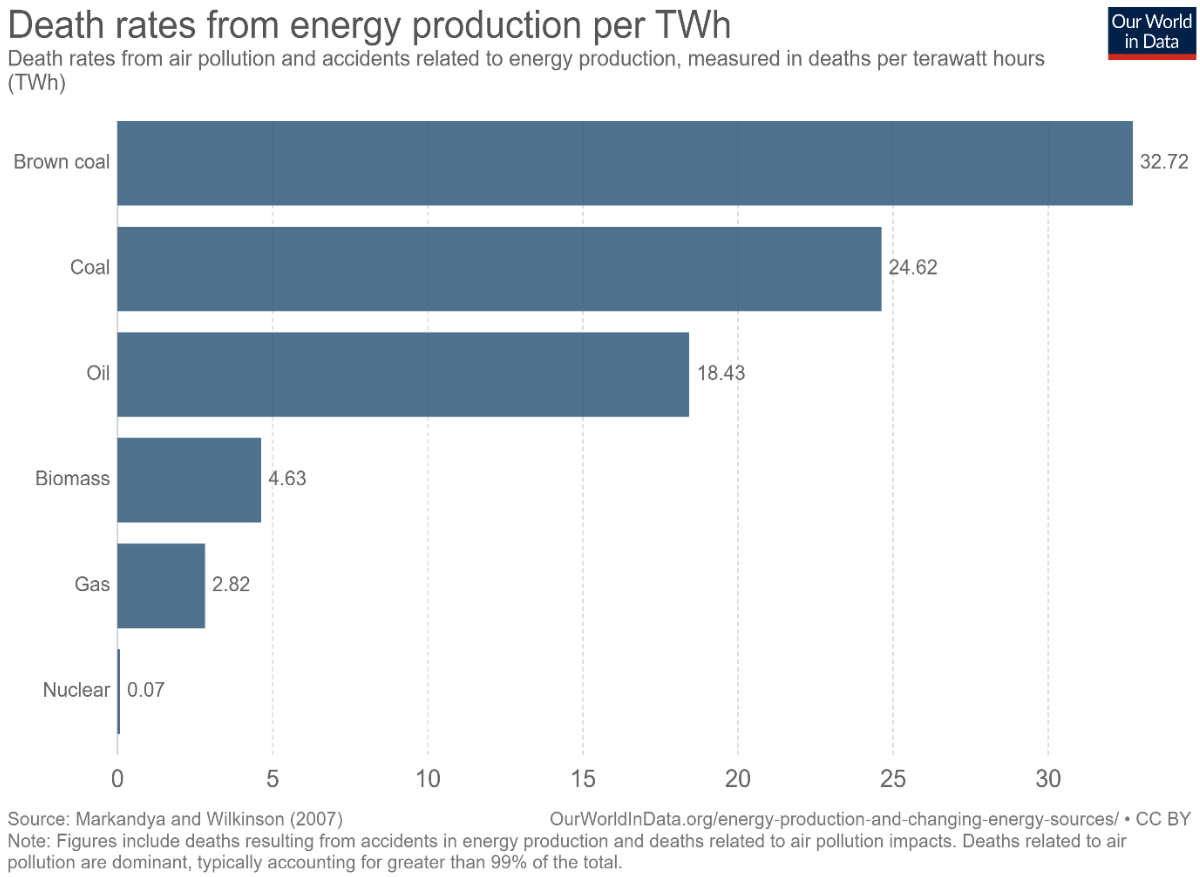
- **Uranium exporter:** With the largest known reserves of uranium in the world, Australia is a key supplier of uranium to the EU, China, India, Japan, South Korea and the US for use in civilian nuclear power plants to generate clean electricity to millions every year.

2. Safety:

Globally, nuclear energy remains one of the safest forms of electricity generation available to humanity. Nuclear power's safety has been well documented in numerous reports and studies over the past 40 years.

Markandya and Wilkinson in the medical journal *The Lancet* noted that nuclear power had "one of the smallest levels of direct health effects"[4], including the Chernobyl nuclear accident in the former Soviet Union. They determined that the death rates from energy production per Terawatt hour (TWh) from air pollution and accidents related to nuclear was 0.07, in comparison to brown coal at 32.72 and coal at 24.62[5]. This is outlined in the Graph 1 below from the economist Max Roser's website Our World in Data (https://ourworldindata.org/what-is-the-safest-form-of-energy).

Graph 1:



Nuclear power plant safety has improved significantly since the 1980s as a result of technological improvements and a better understanding of the technology since the days of Chernobyl, Three Mile Island and more recently Fukushima. Concerns regarding another Chernobyl or Fukushima-style incident remain high in the public imagination, reinforced by popular culture references such as HBO's *Chernobyl, The China Syndrome* and *The Simpsons*. These accidents have killed relatively few people in comparison to other sources of energy such as hydroelectricity or fossil fuels as highlighted above. No one died as a result of Three Mile Island, while there have been no radiation deaths attributed to the Fukushima accident, in comparison to the thousands who perished in the earthquake and subsequent Tsunami.[6]

The reality is that designs connected to previous nuclear power plant accidents are no longer on the market and thus out-of-scope for consideration. Newer advanced reactor designs (such as Small Modular Reactors (SMRs)) that are coming online or in development are inherently safe as they are designed to operate on the laws of physics rather than use 'active' safety mechanisms.[7] This makes the possibility of a Chernobyl-style event significantly reduced or simply physically impossible.

Finally, regarding the management of nuclear waste, the 2016 South Australian Nuclear Fuel Cycle Royal Commission extensively assessed and demonstrated that the management of nuclear waste is a well-developed process, backed by decades of scientific understanding and knowledge.[8] There are negligible environmental, or health impacts/risks posed by nuclear waste, as a result of nuclear energy having a closed-fuel cycle, that sees nuclear waste encapsulated, stored or recycled in purpose-built facilities.

3. Human Health Impacts

Pollution and emissions: It is well-documented that burning of fossil fuels such as brown and black coal release a range of pollutants and emissions into the atmosphere and surrounding environment. These include smoke particulates, sulphur and nitrogen oxides, heavy metals and radioactive elements. All of these are linked to adverse health impacts[9]. Nuclear power is a proven source of energy that emits no emissions or pollutants. Hansen and Kharchea highlighted in 2013 that nuclear power provided "a large contribution to the reduction of global mortality", calculating "a mean value of 1.84 million human deaths prevented by world nuclear power production from 1971 to 2009, with an average of 76,000 prevented deaths/year from 2000 to 2009."[10]

Radiation: Exposure to radiation remains one of the principle concerns people have when discussing nuclear energy. This is because radiation is not well-understood by the public. Fear and misunderstanding of its effects, reinforced by popular culture (see point 2), remains a major impediment to nuclear energy. However, as a UN Environmental Programme publication noted in 2016:

> "Today, we know more about the sources and effects of exposure to [ionizing] radiation than to almost any other hazardous agent, and the scientific community is constantly updating and analysing its knowledge... The sources of radiation causing the greatest exposure of the general public are not necessarily those that attract the most attention. In fact, the greatest exposure is caused by natural sources ever present in the environment, and the major contributor to exposure from artificial sources is the use of radiation in medicine worldwide."[11]

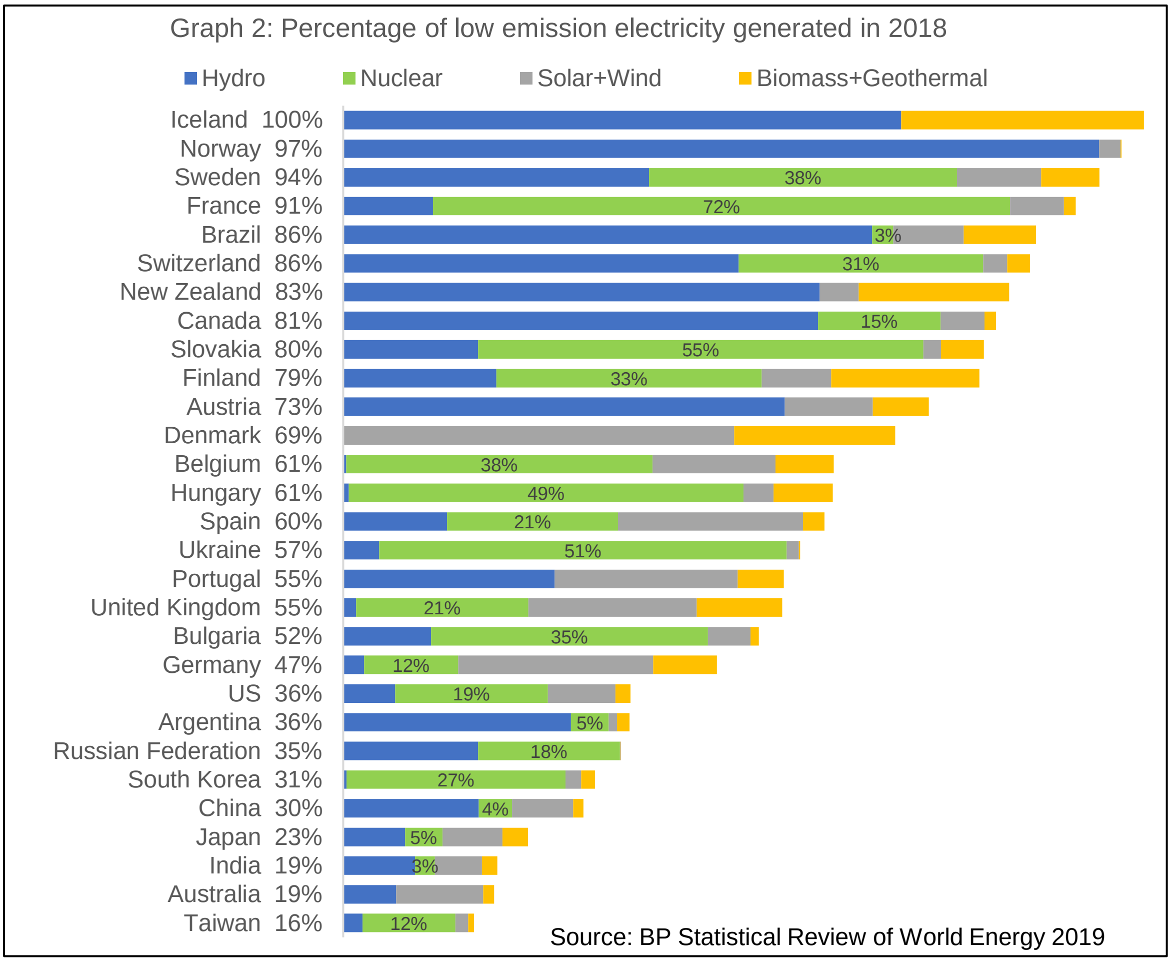
Without downplaying the seriousness of radiation exposure, it should be noted that the use of nuclear energy does not lead to significant radiation exposure for members of the public. In the cases of Three Mile Island and Fukushima no radiation deaths have been attributed to these accidents. It should also be noted that radiation plays a significant role in saving lives and curing disease through nuclear medicine, in which Australia is a world leader.

The World Nuclear Association provides further information on this subject that should be considered by the Committee.

Environmental Impacts:

<u>Carbon Dioxide Emissions:</u> Nuclear reactors are a zero-carbon dioxide technology that have played and will continue to play a key role in reducing carbon dioxide emissions. The International Atomic Energy Agency (IAEA) notes that globally the "use of nuclear power avoids the emissions of nearly 2 billion tonnes of carbon dioxide every year – the equivalent of taking over 400 million cars off the road per year"[12]. Or the equivalent of taking 3.7 Australia's off the planet[13]. According to Hansen and Kharchea, "between 1971 to 2009 world nuclear power generation prevented an average of 64 Gigatonnes of CO2-equivalent".[14] The International Energy Agency (IEA)[15] and the Intergovernmental Panel on Climate Change (IPCC)[16] have stated that nuclear power alongside other technologies can make a significant contribution to cutting carbon dioxide emissions.

It is a proven technology that has assisted in rapidly decarbonizing electricity grids, as demonstrated by data from the BP Statistical Review of World Energy 2019. Graph 2[17] below highlights that it is predominately those countries that have a high share of nuclear power along with hydro and/or intermittent renewables such as wind and solar that generate the most amount of low-emission electricity.



Finally, it remains the only credible low-emission energy source to displace large amounts of fossil fuels outside the electricity sector. Global experience suggests nuclear power could play a major role in Australia providing process heat[18] for desalination, water treatment, synthetic fuel production (hydrogen for example) and industrial heat for steel and other manufacturing.

Other emissions and pollutants: As mentioned in point three above, nuclear energy avoids other emissions and particulates that are produced by burning coal such as sulphur and nitrogen oxides that lead to acid rain and photochemical smog, heavy metals that harm human health and the release of radioactive elements into the surrounding environment.

Material input: Nuclear energy requires less material input (such as steel, concrete, rare earth elements and other materials) than other forms of energy production thanks to its high-power density. As highlighted in a US Department of Energy report in 2015, a conventional nuclear pressurized water reactor only requires 843 tonnes per TWh (tonnes/TWh) of materials compared to Wind's 10,260 tonnes/TWh or Solar's 14,920 tonnes/TWh.[19] Newer SMRs designs will require even less concrete and steel than current conventional reactors.

Land use: Nuclear power plants do not require as much land per megawatt as other low-emission technologies thanks to its high-power density. This was highlighted in a report into the land use of energy technologies in the US with the results shown in Table 1[20] below. Nuclear energy therefore does not suffer from the serious land use or transmissions right-of-way challenges that intermittent renewables do. Newer SMR designs aim to reduce this land use footprint even further.

Table 1 – Land use per energy sources in the US	
Electricity Source	Hectares per Megawatt Produced
Nuclear	5.14
Natural Gas	5.02
Solar	17.6
Wind	28.58
Hydro	127.56

Waste: Energy density of nuclear power's fuel means that in comparison to fossil fuels the amount of waste produced is small. For example, it is estimated that the ash produced by Australia's fleet of coal-fired power stations alone is 12 million tonnes per year[21], compared to the 400,000 tonnes of spent fuel (of which 25% is reprocessed) produced by ALL nuclear power plants ever[22]. This waste is stored securely and safely in spent fuel pools or dry casks requiring little use of land.

Water: Nuclear power plants would have a negligible impact on Australia's water security[23]. Indeed, Nuclear energy can only have a positive impact on ensuring Australia's fresh water is used in a more sustainable manner. Using process heat, nuclear power could assist in desalinating water sources to produce potable water for dry communities. There is well documented global experience where nuclear power plants have been used to desalinate water through reverse osmosis technology.[24]

4. Security and reliability

The secure and reliable flow of electrons is one of the fundamental basic requirements for a functioning modern industrialised state in the 21st century. Unfortunately, generous government incentives to replace coal-fired generation with intermittent renewables such as wind and solar has contributed to undermining the grid's resilience and reliability. This has resulted in the increasing need for the Australian Energy Market Operator (AEMO) to intervene and use reserve powers to maintain the stability of the grid. This situation will only continue to deteriorate as further coal-fired generator exit the market. This is should be of serious concern for Victoria, who, along with other states, have pursued arbitrary renewable targets with little regard for their longer-term impacts to the wider system or electricity market.

Germany's Energiewende (Energy Transition) experience should also serve as a warning to Australian policymakers regarding the immense challenges – political, economic and technical – involved in transitioning solely to a renewable-centric system. This is particularly so as Australia's is isolated from neighbouring grids from which to import and export electricity.

Any gains made by the increased penetration of intermittent renewable technologies has been offset by the political decision to shut down nuclear power post-Fukushima. Germany will continue to burn brown-coal until 2038 and remains dependent upon Russian gas for home heating and electricity generation. A recent McKinsey report[25] has highlighted the significant challenges Germany faces in terms of energy security and its economy, with the power grid repeatedly facing critical shortfalls in available power. McKinsey expects this situation to worsen as further nuclear and coal-fired generation exits.

Such real-world experience highlights the need for energy diversification to retain baseload capacity and offer grid resilience. Nuclear energy offers zero-emission electricity, while being able to provide baseload power and grid resilience. Unlike coal-generators that require constant fuelling or intermittent renewables that require storage or back-up solutions to offset their intermittency, current conventional nuclear reactors can operate 18-24 months at a time until they need to be refuelled. Newer reactor designs such as Terrestrial Energy's Integral Molten Salt reactor will require refuelling every 7 years.[26]

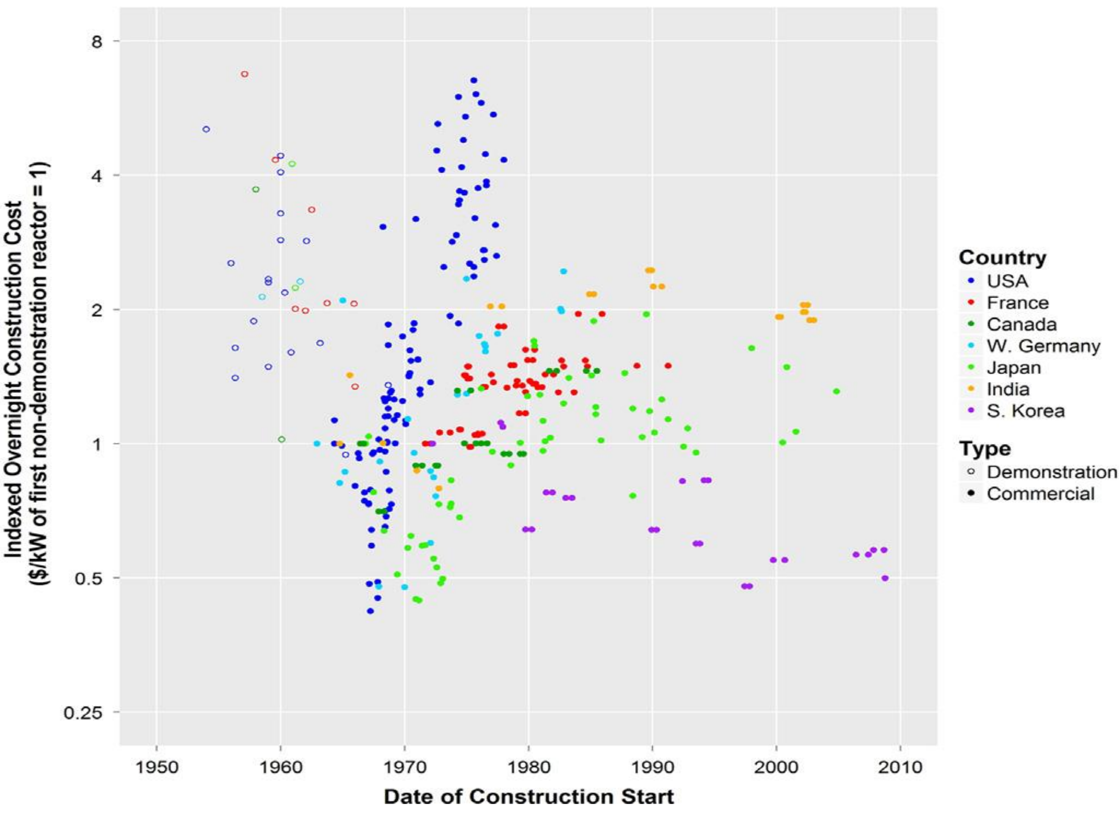
Nuclear power by design is also less susceptible to extreme weather events and climatic variations than other sources of energy, particularly renewable systems dependent on sunshine and/or wind.[27] This makes nuclear power plants significantly less vulnerable to fuel supply disruptions (Oil shocks, gas supply issues) or significant weather events.

5. Economic Feasibility

Replacing coal-based generation with intermittent renewables (wind and solar) inevitably results in escalating system costs as the proportion of intermittent renewables increases. At high levels this will be unaffordable, as is increasingly realised. System costs must be considered on top of levelised costs of generation in order to sensibly assess and compare different sources of electricity. LCOE on its own is misleading.

<u>Capital Costs:</u> One of the predominate arguments brought against nuclear energy is cost – in particular, capital costs. It is acknowledged that conventional reactor builds have been characterised by high start-up and construction costs, especially in the West. The examples of Hinckley Point C (UK) and Olkiluoto (Finland) being cited as the prohibitive cost of nuclear energy. Start up and construction costs, however, vary significantly between different countries and jurisdictions. A paper in 2016 by Lovering et al highlighted that such variance is the result of different material factors, including, to a large degree, regulation burdens, as demonstrated by the US and South Korea. While nuclear build costs have continued to rise in the US as result of its increased regulation, in South Korea construction costs have declined by 50% since the first nuclear reactor was built in 1971, or the equivalent of a 2% decrease per year, as shown in Graph 3 below.[28] Clearly in the right settings, nuclear power's capital costs can and will decline.

Graph 3 – Overnight capital costs. Lovering



In addition, it is anticipated that advanced reactor designs will address many of the construction cost issues that have long plagued nuclear projects in the West. Standardisation and modularity will assist in driving down the overnight and indirect costs, while mitigating construction risks and delays.[29] Even so, the contemporary experience of South Korea and United Arab Emirates, demonstrates that nuclear remains one of the most reasonable and affordable pathways to decarbonisation on a large-scale.

System Costs: Much of the focus of the energy debate when discussing different energy technologies focuses on the Levelised Cost of Energy (LCOE). It is a measurement used to compare different generation technologies based on the unit-cost of electrical energy over the lifetime of a generating asset. While it is a useful measure, it does not take into account the dispatch characteristics of a technology nor the full costs that will be imposed on the energy system such as transmission and other supporting infrastructure (back up and storage). LCOE is often used by opponents of nuclear energy as proof that is too costly in comparison to intermittent renewable technologies such as wind and solar and justify a transition to a 100% renewable system.

A number of studies into 100% renewable systems have shown that there is "a high degree agreement on several key features of renewable centric power systems that are likely to make these systems more costly and challenging than balanced low-carbon power systems employing a diverse portfolio of resources." [30] This is due to the need to offset the intermittency of wind and solar energy technologies. Indeed, a recent Organisation for Economic Cooperation and Development (OECD) study highlighted that "the most efficient manner to achieve the ambitious emission objective of 50g CO_2 per Kilowatt hour (KWh) is to rely on nuclear power and hydroelectricity as dispatchable low-carbon generating solutions rather than on wind and solar PV."[31] It concluded that:

> "If OECD policy makers want to achieve such a deeply decarbonised electricity mix they must foster vigorous investment in low-carbon technologies such as nuclear energy, VRE and hydroelectric power. Where hydroelectric power is constrained by natural resource endowments, nuclear and VRE remain the principal options."[32]

Therefore, policymakers must carefully consider the full system implications and costs of an energy policy that cherry picks technological solutions based on the fashion of the day, rather than the medium to long-term needs of the energy market.

Consensus and community engagement:

For nuclear energy to be adopted in Victoria and more broadly Australia, politicians and policy makers must engage and convince the public that it is required. As Emeritus Professor of Physics Wade Allison from the University of Oxford stated, "The evidence makes plain the need for a root-and-branch cultural change in attitudes to nuclear technology."[33] There is no hiding from the fact that like any major change or reform, be it water fluoridisation, gun laws or financial deregulation, this will be at times challenging and face resistance from a vocal and ideologically motivated minority.

Yet there are indications that after years of public aversion to nuclear energy in Australia, this is beginning to wane. This observation is based on a series of polls conducted by various news and media outlets over the past 12 months[34]. This includes the recent Roy Morgan poll that demonstrated "a narrow majority of 51% (up 16% since 2011) of respondents say Australia should develop nuclear power to reduce Australia's carbon dioxide emissions."[35] Further to this industry groups are starting to seriously consider the option of nuclear energy, as indicated by Industry Super Australia's public support earlier this year[36] and more recently the Australian Workers Union[37].

Reasons for this change may be that in the age of climate change action, electricity price hikes and reliability concerns, much of the original rationale underpinning Australians' aversion to nuclear energy no longer applies. As a result, there is scope for politicians, policy makers and industry leaders to engage further with the public on the potential of nuclear energy in Victoria and Australia. This should start with discussions around lifting the current state prohibition on nuclear power and uranium mining to allow further feasibility and development assessments to progress. If successful, Victoria should also lobby the Federal Government and opposition parties to reconsider its current prohibition on nuclear energy.

Removal of the prohibition on nuclear power:

Victoria's current nuclear energy prohibition, along with the Commonwealth prohibition, remain the biggest barriers to the consideration and adoption of nuclear power in Victoria. These prohibitions continue to inhibit any further assessment on nuclear energy feasibility and development in the state and more broadly speaking Australia. It also continues inhibit further community engagement and building of national consensus on this issue. It is time for Victoria's antiquated and unjustified prohibition on nuclear energy and uranium mining to be lifted to allow for a true technologically agnostic approach to electricity generation and energy in Victoria. Furthermore, it would provide an impetus the Federal government and other state governments to lift their current prohibitions on nuclear energy and/or uranium mining.

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