NUCLEAR FOR CLIMATE AUSTRALIA

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Submission to:

Department of Industry, Science, Energy and Resources

Commentary on Technology Investment Roadmap Discussion Paper

Dated: 11th June 2020

Due: 21st June 2020

1. Introduction

The Technology Investment Roadmap Discussion Paper strongly promotes the development of sub $2/kg hydrogen. This is not an opportunity for strong emissions reductions maintaining as it does the use of fossil fuels. Far superior options exist with the use of nuclear energy. Each of the following sections is headed with the wording of the stakeholders views sought by the draft Roadmap paper.

2. The challenges, global trends and competitive advantages that should be considered in setting Australia's technology priorities,

2.1. The Challenges

The greatest challenge was set 28 years ago when Australia became a signatory to the United Nations Framework Convention on Climate Change in Rio. We have known since then that by 2050 our economy wide emissions need to be below **50 gr CO2e/kWh** if we are to hold global temperature increases to below 2 degrees.

Successive state and federal governments in Australia have known how to achieve extremely low emissions in electricity generation through the use of nuclear energy. The evidence is clear. We see it daily in the emissions profiles of:

- France which generates electricity with an emissions intensity of only **35 gr. CO2e/kWh**[1] in 2019 from a grid supplied with 75% nuclear energy. Carbon intensity of the nuclear sector is only **13 gr CO2e/kWh**[2]
- Sweden with Forsmark and Ringhals nuclear power stations having production carbon intensities of only **6 gr CO2e/kWh**[3]
- Finland's Kivisto nuclear power plant having an emissions intensity of **10 - 26 gr CO2e/kWh**

[1] https://www.rte-france.com/en/eco2mix/chiffres-cles-en
[2] https://www.world-nuclear.org/information-library/energy-and-the-environment/co2-implications-of-electricity-generation.aspx
[3] https://www.world-nuclear.org/information-library/energy-and-the-environment/co2-implications-of-electricity-generation.aspx

Despite these glowing examples, within Australia the sway of the Variable Renewable Energy (VRE) message is strong. This has resulted in electricity cost escalations, high emissions and decreased reliability of supply. **No nation has achieved emissions reductions of the level required to address climate change using predominantly wind and solar.**

Within South Australia the failure of renewables firmed by gas to achieve effective emissions reductions can be seen in Figure 1. No accurate monitoring of Australia's fugitive emissions has been carried out and so South Australia's emissions intensity is uncertain and is likely to exceed **400 gr CO2/kWh**.

The ultimate expression of the failure of efforts to firm up renewables can be seen in policies such as the German Energiewende where despite spending some €150 billion up to 2015, the actual emissions reductions have remained stubbornly high as shown in Figure 2. By 2025 it's been estimated by the Düsseldorf Institute for Competition Economics that over €520 billion will be spent in the electricity sector alone.

Australia cannot afford to go down the German route on renewables – it is not affordable and instead we need to look at proven solutions such nuclear energy.

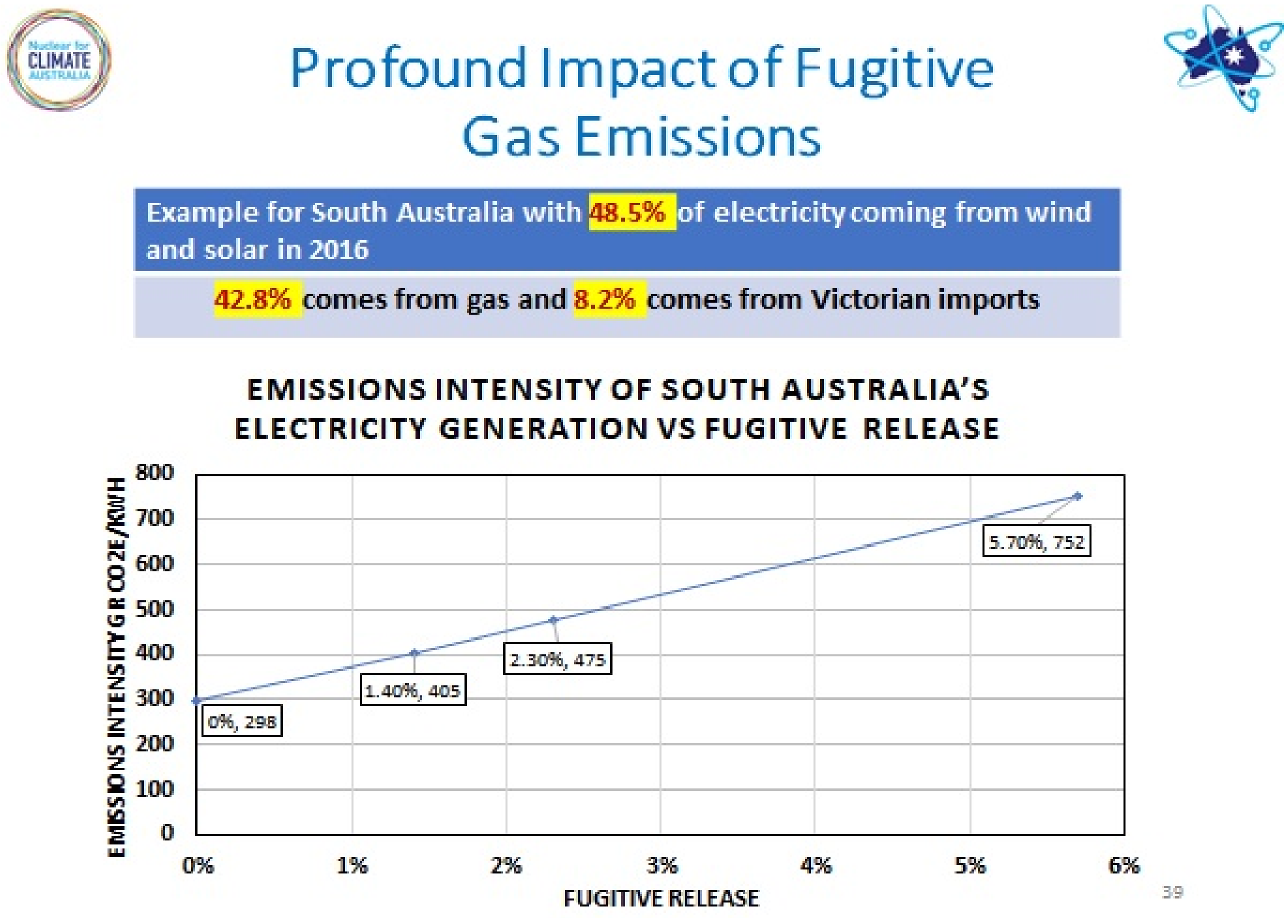

Figure 1 – Impact of gas on emissions intensity in South Australia

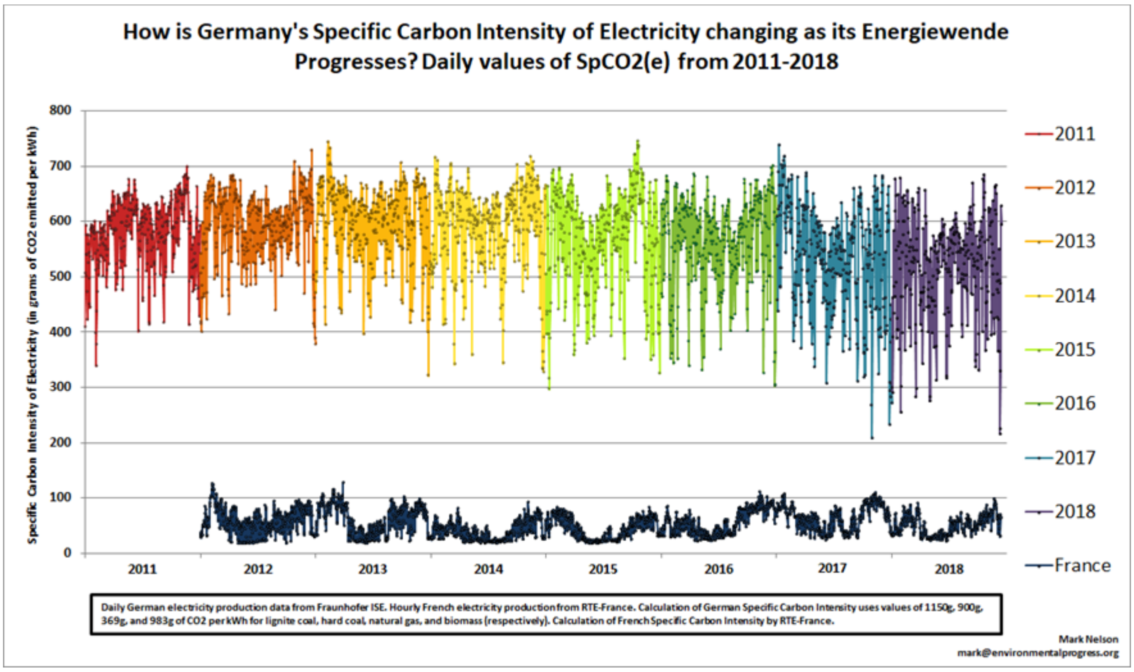

Figure 2 - French vs German electricity emissions intensity

3. The shortlist of technologies that Australia could prioritise for achieving scale in deployment through its technology investments

3.1. Priority Technologies listed in Figure 7

Australia is on an energy precipice and with two available options. Our choice should depend on our predicted system levelised cost of energy (SLCOE).

The costs of our transmission, distribution and system services significantly exceed our costs of generation and so the two options can be described as:

a) A consolidated grid with localised very low carbon load following nuclear power plants. Variable demands would be met by hydro, pumped storage, large scale solar and a minor amount of open cycle gas.

b) A disbursed grid containing wind, solar, pumped and battery storage, hydro and large amounts of open cycle gas turbines together with substantial amounts of grid ancillary services

Figure 7 of the Technology Investment Roadmap clearly assumes a renewable energy future outlined in option b) is being followed – it does not demonstrate technological neutrality, economic precedent or an appreciation of the principles that arrive at a SLCOE.

3.2. Sources of nuclear energy?

Figure 7 only mentions Small Modular Reactors while Figure 4 shows them to be technically immature with an unrealistically high cost in terms of $NPV/tonne CO2e. This probably reflects the CSIRO's GenCost 2019-20 which claims SMR's cost $16,200/Kw and have an LCOE of approx. $300/MWh.

This is challenged as CSIRO have failed to substantiate these costs. Further their report is entirely silent on the deployment or costs associated with Gen III/III+ large scale plants. Had they been included in their Figure 4 nuclear power plants would have had the greatest potential for abatement at the least cost.

Currently available light water reactors could be installed on the National Electricity Market (NEM) in the near term and have a nett power output of approximately 1,100MWe.

Capital cost is estimated at A$6,200/kw with an LCOE of $79/MWh

Medium term availability of Small Modular Reactors (SMR's) with outputs of around 300MWe or less are an ideal fit on the NEM. The simplest and most straightforward of these designs is General Electric's BWRX 300MWe unit which should be available after 2027.

Alternatively, there is NuScale's 360MWe or 720MWe which would likely be available after 2026. A similar timescale applies.

Anticipated cost of the General Electric plant is A$4,000/kW with an LCOE of $63/MWh

The LCOE's of large and small nuclear power plants are shown on Figure 3 together with the average wholesale electricity prices on the NEM. Also included is the Monthly energy demand line.

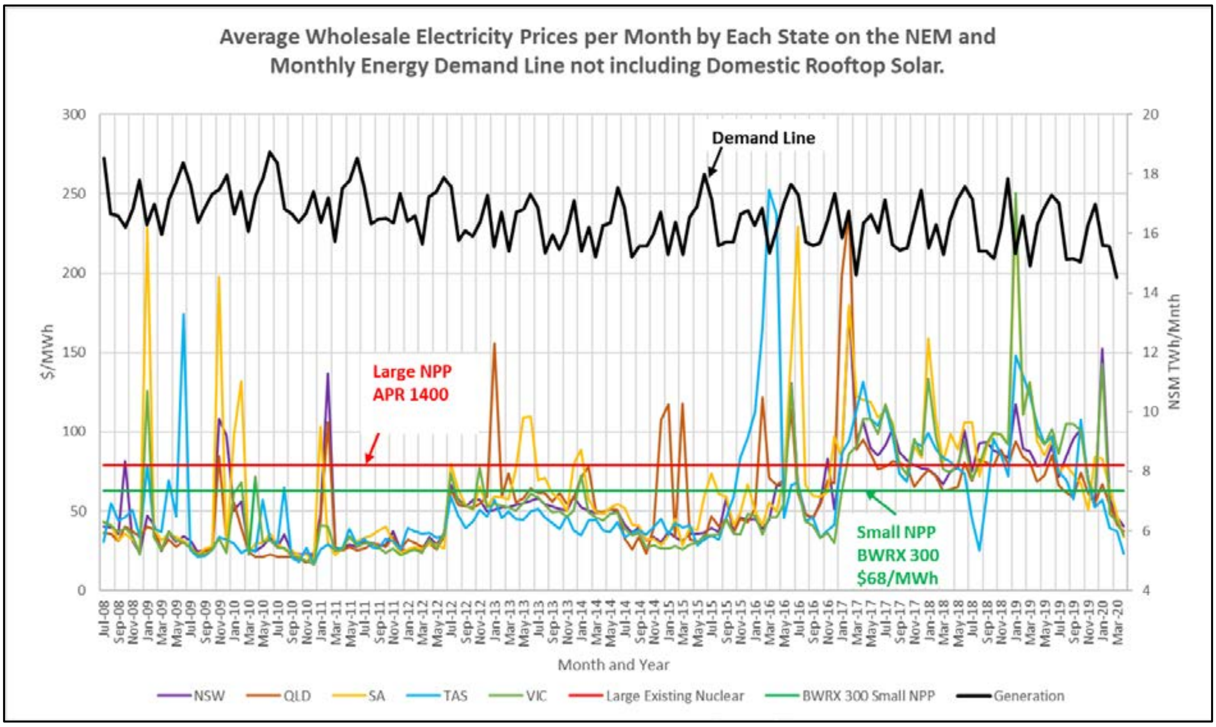

Figure 3 - Viability of Nuclear Energy on the NEM

3.3. Economic

We frequently hear claims that wind and solar generators with batteries or pumped hydro storage are now lower cost than coal, nuclear or gas generators. Often this is based on simplistic Levelised Costs of Energy (LCOE) calculations that fail to include system costs.

These include:

- Intermittency and variability requiring backup to operate over a wide range of outputs.
- Underutilised backup generators which operate on stop start cycles over high ramp rates.
- Ancillary services required for grid stabilisation,
- Balancing costs caused by ensuring sufficient reserve capacity is available to meet the needs of uncertain variable renewable output.
- Grid costs reflecting the increased costs for transmission and distribution due to the distributed nature of Variable Renewable Energy (VRE) generation plants operating at low capacity factors.
- Grid connection costs of a significant number of VRE generators.

To address these impacts Dr Robert Barr and colleagues worked on a model of the NEM which calculates the System Levelised Costs of Energy.

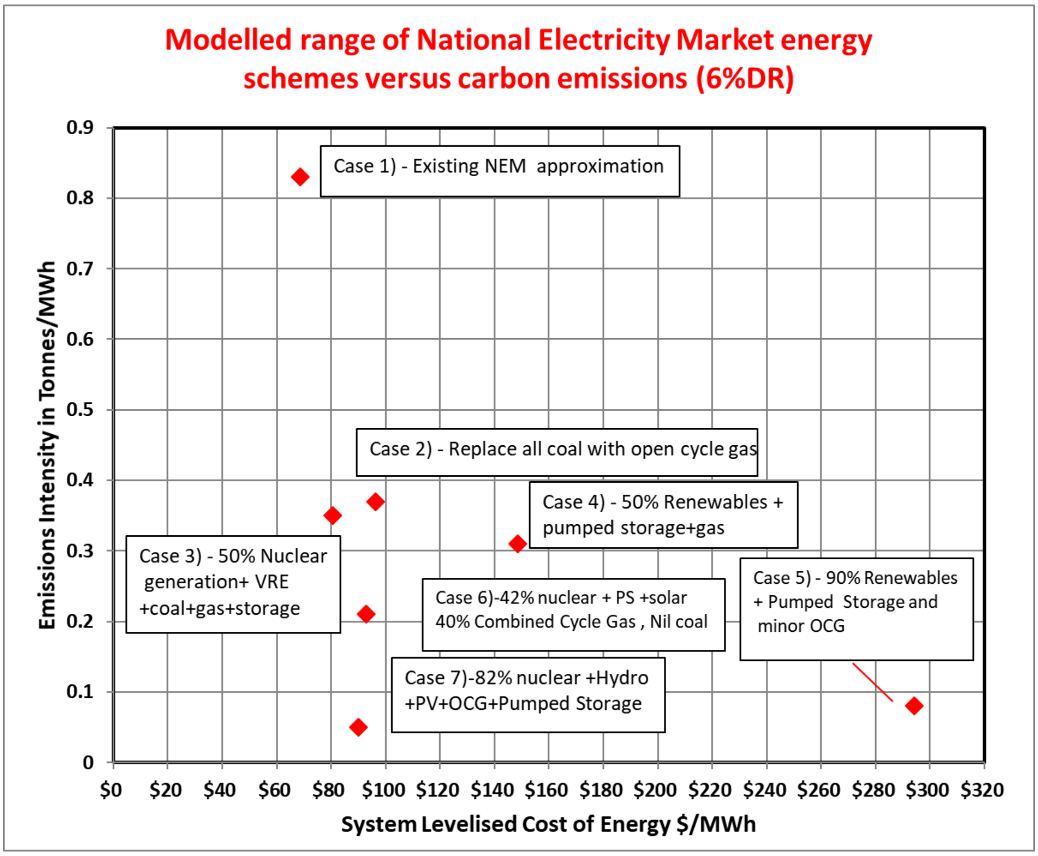

Figure 4 - Modelled range of NEM energy schemes showing cost and emissions intensity

Seven generation combinations have been analysed using load and generation data provided by the Australian Energy Market Operator for each period of 30 minutes over the year 2017. The results are shown in Figure 4

The results of this comparative analysis show that a system which includes nuclear energy such as Cases 3,6 and 7 will be substantially lower cost than systems that exclude it such as Cases 4 and 5.

Nuclear for CLIMATE AUSTRALIA

4. Goals for leveraging private investment.

Action is being taken globally to reduce carbon emissions. In Australia placing a price on carbon is resisted because its perceived as being a “drag” on the economy. It is claimed for example that we did not need to tax horses in order for people to switch to motor vehicles.

This is flawed thinking and a better metaphor is that of taking out the garbage. It’s illegal to dump our garbage on common ground and we effectively pay an imposed price for its collection to prevent suffering from health impacts. Likewise, paying for the privilege of dumping carbon in the environment will inevitably stimulate alternatives.

Therefore, we can lever private investment by:

- Creating a defined price on carbon,
- Increasing the price to match a defined time frame for decarbonising the Australian economy
- Removing legislation that prevents the exploitation of all low carbon technologies – specifically nuclear energy.

5. What broader issues, including infrastructure, skills, regulation or, planning, need to be worked through to enable priority technologies to be adopted at scale in Australia.

5.1. Nuclear Power Generation - Wealth creation and employment

With the retirement of the aging coal fired power stations in Australia there is room for 1.1-Gigawatt nuclear power plants.

An employment and economic analysis of such a single unit plant was recently completed in Finland for its new Hanhikivi 1 nuclear power plant.[i] This indicates that for a similar plant in Australia:

- 20,000 people would be employed during the course of construction
- Up to 4,000 would be working simultaneously
- 500 people would be employed during plant operations in very highly technically fulfilling roles.
- 2,600 jobs would be created by the cascading effect on training, education, accommodation and allied industries

Nuclear energy represents an opportunity for the industrial renewal of the Australian manufacturing sector.

A fleet of nuclear power plants can have steadily increasing the local content as happened in France, South Korea, Japan and more recently in China. The same could happen in Australia. The first plants could have at least 70% local content. As Figure 5 and Figure 6[ii] show this could steadily build into the higher skilled areas which in practice only make up a small part of the project value.

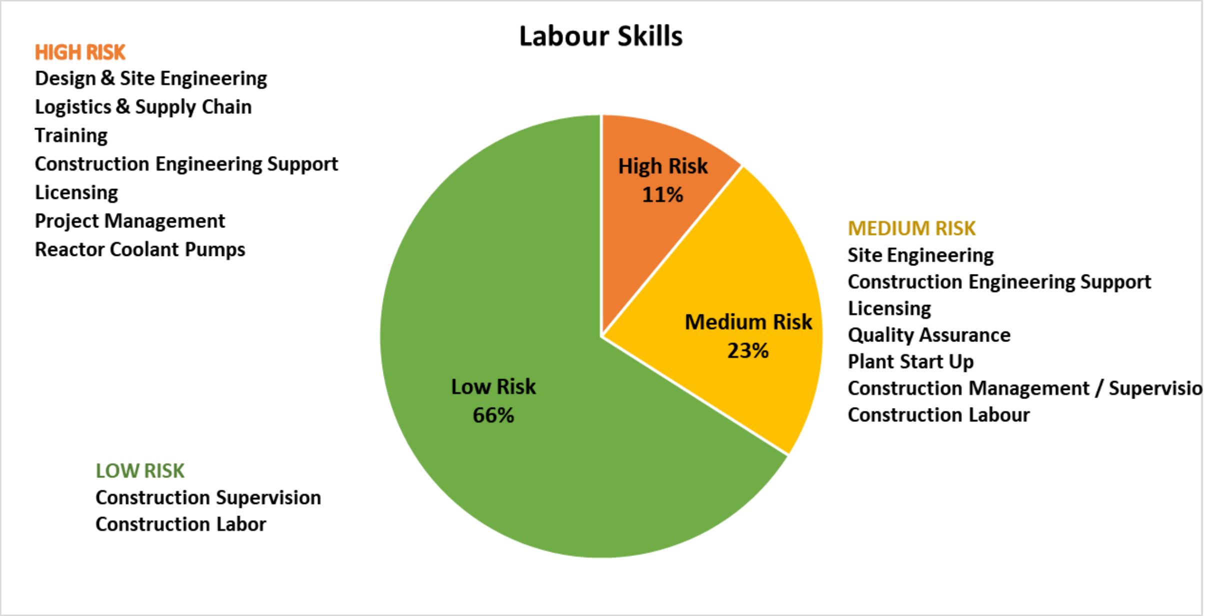

Figure 5 - Proportion of Labour

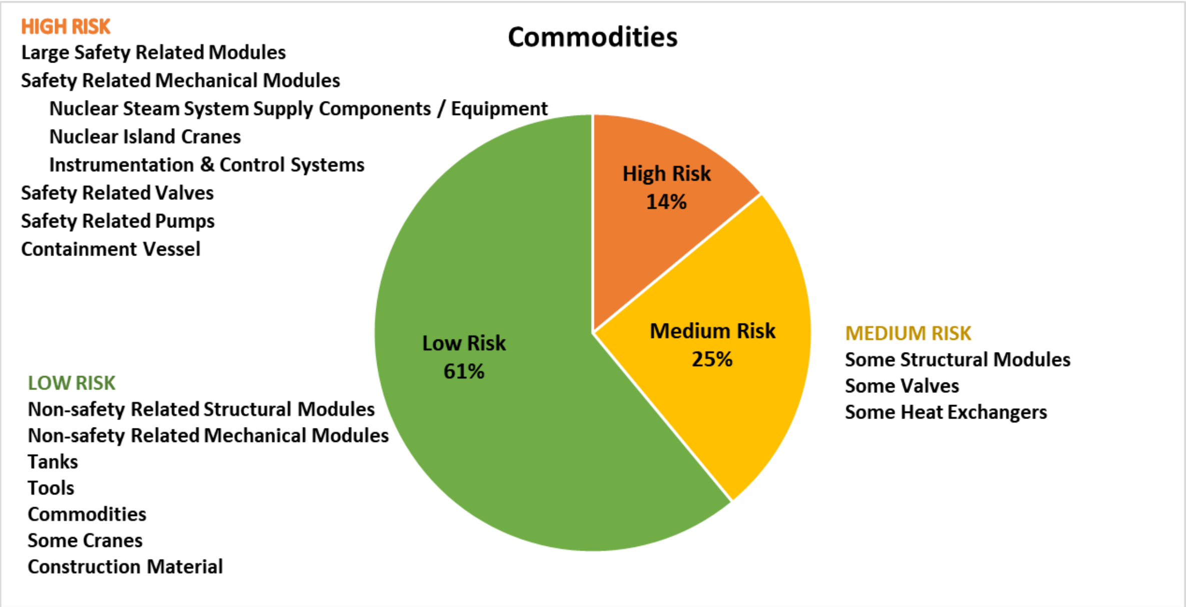

Figure 6 - Proportion of Commodities

6. Where Australia is well-placed to take advantage of future demand for low emissions technologies and support global emissions reductions by helping to deepen trade, markets and global supply chains.

6.1. Management, Storage and Disposal of Nuclear and Radioactive Waste

A further opportunity for Australia to participate very profitably from the nuclear fuel cycle was identified by the South Australian Nuclear Fuel Cycle Royal Commission (NFCRC). It was recommended that the South Australian Government pursue the opportunity to establish used nuclear fuel and intermediate level waste storage and disposal facilities in South Australia.

The storage of used nuclear fuel from geographically smaller nations such as Taiwan, South Korea, Belgium or even Japan presents an opportunity to expand nuclear energy to reduce the world's carbon emissions. This single storage facility could present the greatest contribution that Australia could make to the World's emissions reductions.

The following text is drawn from the summary of the NFCRC.

There is international consensus that deep geological disposal is the best available approach to long-term disposal of used fuel. The Commission has found that there are now advanced programs in a number of countries that have developed systems and technologies to isolate and contain used nuclear fuel in a geological disposal facility for up to one million years. The most advanced of these will commence operation in the 2020s.

The safety of deep geological disposal is assured through the combined operation of geology and engineered barriers, and a detailed understanding of the radiological risks associated with used nuclear fuel. The evolution of geological conditions during the past hundreds of millions of years is well understood, and therefore future behaviour over hundreds of thousands of years can be predicted with confidence following detailed study. Engineered barriers are designed and constructed to complement the surrounding geology, and thereby provide a passively safe system of isolation and containment. The predicted future interactions between the used fuel, the engineered barriers and the surrounding geology are complex, but can be modelled and tested with a high degree of precision

..,..the Commission determined that a waste disposal facility could generate $51 billion during its operation (discounted at the rate of 4 per cent). Further analysis indicated that by accumulating all operating profits in a State Wealth Fund, and annually reinvesting half the interest generated, a fund of $445 billion could be generated over 70 years (in current dollar terms).

Such a facility could be constructed and operated in Australia which has substantial regions of geologically stable granite.

Robert Parker

Founder of Nuclear For Climate Australia and

Vice President, Australian Nuclear Association

https://nuclearforclimate.com.au/

www.nuclearaustralia.org.au

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[i] A study on positive effects of the large-scale project https://www.fennonen.fi/en/article-page/study-positive-effects-large-scale-project

[ii] Introduction to Westinghouse and The AP1000® Plant, 2017.