AUSTRALIAN NUCLEAR ASSOCIATION INC.

PO BOX 472, ENGADINE, NSW 2233, AUSTRALIA

Email: ANA@nuclearaustralia.org.au
Web: www.nuclearaustralia.org.au

Submission to

House of Representative Standing Committee on Environment and Energy

Inquiry on the Prerequisites for Nuclear Energy in Australia

15 September 2019

Summary of Submission

Nuclear power is a technology widely used around the world to generate reliable, affordable and low carbon electricity.

The Australian Nuclear Association (ANA) recommends repeal of the prohibitions in the ARPANS Act and the EPBC Act so that nuclear power can be considered on its merits as part of Australia's future energy system.

Removing the nuclear prohibition in the EPBC Act would allow an Environmental Impact Statement for a nuclear power plant to be assessed and the Minister to make a determination on its environmental impact.

ANA recommends that the ARPANS Act be amended to remove the prohibition against nuclear power plants and that ARPANSA be the national regulator for licencing the siting, construction and operation of any nuclear power plant in Australia. Regulatory agreements will be required between ARPANSA and the regulator in State or Territory where a nuclear power plant is proposed.

Australia already has the prerequisites for managing low and intermediate level radioactive waste from experience with existing low and intermediate level waste in Australia. Options for managing spent fuel from nuclear power reactors will be available when the spent fuel has to be moved from cooling ponds at the power plant. Dry cask storage modules for spent fuel are commercially available.

Analysis of system levelised costs of electricity (SLCOE) for coal, gas, nuclear and renewable generation options for both Australian and overseas systems show that electricity costs in deep decarbonisation scenarios needed by 2050 are more than halved when nuclear is included compared to systems using only variable renewable energy (wind and solar) systems. Costs of recent builds of Gen III+ nuclear power plant shows that nuclear power can be economically competitive with other electricity generating technologies over the life of the nuclear power plant.

Nuclear energy must be included in the options to achieve cost effective decarbonisation of Australia's energy system. Decarbonising our electricity system will need an optimum economic mix of all low carbon technologies.

The ANA strongly recommends nuclear energy be included in investigations of Australia's future energy system.

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1. Australian Nuclear Association

The Australian Nuclear Association is an independent incorporated scientific institution with members from the professions, business, government and universities with an interest in nuclear topics. Many of our members are professional scientists and engineers with considerable experience and expertise in nuclear topics.

The Australian Nuclear Association supports the use of nuclear science and technology in Australia, including nuclear techniques in research, industry and medicine; research reactors as a source of neutrons for research and production of radioisotopes; and nuclear power plants to produce electricity.

The Australian Nuclear Association strongly supports the use of nuclear power for Australia as a reliable, large scale and low carbon generator of electricity and as a low carbon source of heat for industry. Australia can benefit from current and emerging advanced reactor designs as well as from the considerable international experience accumulated in regulating nuclear power reactors, taking into account safety, environmental, technical, economic and social factors.

2. Nuclear Power – a Technology Widely Used Around the World

Nuclear power is a major generator of electricity in most advanced and many developing countries where it is considered an essential part of their electricity supply.

Nuclear power is a very well-established technology with over 17,000 nuclear power plant-years of commercial operation since the first commercial nuclear power plants started in the 1950s.

At the end of 2018, there are about 450 nuclear power plants in service in 30 countries and about 55 nuclear power plants under construction [IAEA 2019]. In 2017, nuclear provided 10.2% of the global electricity and about 18% of the electricity of OECD countries. [IEA 2019a]

Nuclear power plants are very reliable operating at a high capacity factor – in 2018 the global average capacity factor was 79.8% [WNA 2019a] - providing dispatchable electricity 24 hours per day. The very low carbon emissions of nuclear power greatly assist these countries in meeting international carbon emission commitments.

Nuclear could make a significant contribution to the reliability of Australia's electricity grid and reduce carbon emissions. Historically, nuclear was not needed when Australia could rely on its extensive reserves of low-cost coal.

Australia can benefit from current and emerging nuclear power plant designs as well as from the considerable international experience accumulated in regulating nuclear power plants, taking into account safety, environmental, technical, economic and social factors.

Australia is increasingly faced with power prices that are destroying the competitiveness of our manufacturing sector despite the commitment to renewables. Together with the urgent need to meet international carbon emission commitments, nuclear is a real option to be part of Australia's energy future and make a very significant contribution to improving energy cost and reliability and lowering carbon emissions of Australia's power system.

3. Prohibitions in Federal Legislation Should be Repealed

Notwithstanding that nuclear has a very good record overseas in supplying reliable, affordable and low carbon electricity, the Parliament has historic prohibitions against nuclear power and other nuclear facilities in the Australian Radiation Protection and Nuclear Safety Act 1998 (ARPANS Act) and the Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act). Repealing the prohibition against nuclear facilities would allow proposals for nuclear power plants to be considered on their merits as part Australia's energy system. It would allow but not ensure their introduction.

Vendors cannot consider proposals for using nuclear in Australia nor collaborate in realistic costings when the technology itself is prohibited. Now is the time to remove the Federal prohibitions to allow nuclear to be considered on its merits as part of Australia's energy future.

Much of Australia's coal generation plant is aged and due for retirement in the next decade. Putting nuclear plant near or at locations of retiring coal plant would benefit from existing grid connections and provide continuing employment in regional locations.

Recommendation 1: The ANA recommends repeal of the nuclear prohibitions in the ARPANS Act and the EPBC Act so that nuclear power can be considered on its merits as part of Australia's future energy system

Terms of Reference

A. Waste Management, Transport and Storage

Nuclear power stations during operation generate a range of radioactive and non-radioactive wastes. There is extensive overseas experience on the safe management of wastes from nuclear power plants and Australia already has a well-developed and effective regulatory regime for the safe and effective management of radioactive waste.

The non-radioactive wastes are similar to those from many large industrial plants and would be readily managed using the waste management infrastructure in the States and Territories.

The radioactive waste from a nuclear power plant would be classified using existing classifications in the Australian Safety Guide on Classification of Radioactive Waste (ARPANSA 2010) RPS20.

This Safety Guide defines six categories of waste

(1) Exempt waste (EW): Waste that meets the criteria for exemption from regulatory control for radiation protection purposes.

(2) Very short lived waste (VSLW): Waste that can be stored for decay over a limited period of up to a few years and subsequently exempted from regulatory control.

(3) Very low level waste (VLLW): Waste that does not meet the criteria of EW, but does need a moderate level of containment and isolation and therefore is suitable for disposal in a near surface, industrial or commercial, landfill type facility with limited regulatory control.

(4) Low level waste (LLW): Waste that is above exemption levels, but with limited amounts of long lived radionuclides. Such waste requires robust isolation and containment for periods of up to a few hundred years and is suitable for disposal in engineered near surface facilities.

(5) Intermediate level waste (ILW): Waste that, because of its content, particularly of long lived radionuclides, requires a greater degree of containment and isolation than that provided by near surface disposal. Waste in this class requires disposal at greater depths, in the order of tens of metres to a few hundred metres.

(6) High level waste (HLW): Waste with activity concentration levels high enough to generate significant quantities of heat by the radioactive decay process or waste with large amounts of long lived radionuclides. Disposal in deep, stable geological formations usually several hundred metres or more below the surface is the generally recognised option for disposal of HLW.

A typical 1000 MW(e) reactor (pressurized water reactor (PWR)) will generate about 100–200 cubic metres of LLW and ILW per year (IAEA 2013, No. NW-T-1.24). Australia already has accumulated almost 5,000 cubic metres of radioactive waste (around the volume of two Olympic size swimming pools). This does not include uranium mining wastes, which are disposed of at mine sites.

There is considerable experience in Australia in managing the storage of low and intermediate level waste, and transporting it see for example the Safely Guide for the Predisposal Management of Radioactive Waste (ARPANSA 2008). There are numerous radioactive waste stores around Australia and the Commonwealth is currently selecting a site for establishing a National Radioactive Waste Management Facility for the long-term disposal and storage of low and intermediate level radioactive waste.

Such a central facility for managing and disposing of low and intermediate level waste would be beneficial to the operation of a nuclear power plant but is not essential. If in the unlikely event that the national radioactive waste management facility is not operational by the time a nuclear power plant is operational, then waste from the nuclear power plant would be stored in an interim storage facility like the other radioactive waste already existing in Australia.

Nuclear power plants also produce spent fuel or high level waste which is solid and emits intense radiation which would be very hazardous if not shielded. Spent fuel from nuclear power reactors and high level radioactive waste are routinely and safely stored and transported in countries with nuclear power.

Spent fuel discharged from a nuclear power reactor is initially stored in cooling ponds usually on the reactor site. When first removed from the reactor, the spent fuel needs cooling to remove heat generated by the radioactivity in the spent fuel element. The heat generated in the spent fuel element decreases over time.

The design and regulation of these short term (typically 10 years) storage facilities is part of the design and licensing of the reactor.

Once the heat generation is low enough, the spent fuel can be sent for reprocessing or placed in longer term dry storage facilities. Many nuclear power plants use dry ventilated modules for storing spent fuel after the initial decay period. Commercially available dry storage modules for spent fuel are very robust and provide full shielding.

A typical operating 1000 MWe Pressurised Water Reactor (PWR) generates about 25 to 30 tonnes spent fuel a year. A 1000 MWe CANDU produces around 125 tonnes a year but of lower specific activity than the PWR fuel. (IAEA 2013 No. NW-T-1.24). These amounts of spent fuel are relatively small and readily managed.

Spent fuel and high level waste from reprocessing spent fuel need to be stored for 40 to 50 years to allow the heat generation rate to decay sufficiently to allow disposal in a geological facility.

Spent fuel from most power reactor contains partially enriched uranium and other actinides that can be reused in nuclear fuel. Some countries reprocess the spent fuel to extract these resources, while other countries have decided to dispose of spent fuel directly.

Disposal in a stable geological facility is the preferred disposal option for spent fuel and high level waste. At present, the US Waste Isolation Pilot Plant (WIPP) is the only operating purpose built deep geological facility. Plans for repositories for disposal of spent fuel are well advanced in France, Finland and Sweden.

An Australian *Code for Disposal Facilities for Solid Radioactive Waste* [ARPANSA 2018] is for low and intermediate level waste. This Code could readily be modified to cover disposal facilities for high level waste. The Australian Code is based on the International Atomic Energy Agency General Safety Guide No. GSG-1 Classification of Radioactive Waste (IAEA 2009) which itself covers high level waste.

Australia would have several options if we have spent nuclear fuel, after about 5 to 10 years in the cooling pond.

- Some nuclear fuel suppliers will take back spent fuel

- Spent fuel can be transferred to commercially available dry casks
- Australia might establish a deep disposal facility to take spent fuel waste from regional countries, as investigated by the South Australian Nuclear Fuel Cycle Royal Commission,
- For a limited amount of spent fuel, there has been considerable discussion of disposal in deep boreholes.

Australia's existing radiological regulations are suitable for managing spent fuel and high level waste.

Australia has large areas with very stable geology which could be suitable for deep geological disposal or spent fuel or high level waste. As an example of the low rate of transport of radioactivity, the uranium orebody at Olympic Dam in South Australia was formed about 1600 million years ago and has not moved since.

Summary

> **Australia already has the prerequisites for managing low and intermediate level radioactive waste from a nuclear power program based on experience with existing low and intermediate level waste in Australia.**
>
> **Options will be available for managing spent fuel from nuclear power reactors when the spent fuel is moved from cooling ponds at the power plant.**
>
> **A decision is needed on the agency to licence and regulate the waste management activities at a nuclear power plant (see also discussion below on Health and Safety).**

Terms of Reference

B. Health and Safety

Australia has a strong regulatory regime for managing radiation protection based on the nine regulators in Australia: ARPANSA for the regulation of Commonwealth entities and a regulators in each of the eight States and Territories.

ARPANSA regulates the 20 MW OPAL research reactor at Lucas Heights which is a Commonwealth Facility. ARPANSA also issues permits for import of radioactive substances into Australia and to export high activity substances out of Australia.

Uses of radiation in non-Commonwealth entities are regulated by the State and Territory regulators. National uniformity in regulating the uses of radiation is achieved through the Radiation Health Committee comprising members from ARPANSA and radiation control officers from each State and Territory.

Australia already has a well-established regulatory regime for radiation protection regulations based on the *Fundamentals for Protection Against Ionising Radiation* (2014) and *Code for Radiation Protection in Planned Exposure Situations* (2016). The regulations for radiation protection in the Commonwealth, State and Territories is based on these documents

The existing regulatory regime is adequate for providing radiation protection at a nuclear power reactor, but there is an issue of which regulator would be responsible to a nuclear power plant not owned by a Commonwealth entity.

The State and Territory regulators are responsible to the industrial uses of radioactivity and radiation in their jurisdiction. Internationally most countries, even federal systems like the USA and Canada, have a national regulator for nuclear reactors.

Australia should designate ARPANSA the regulator of nuclear power plants. This would provide a consistent approach should reactors be proposed in more than one State or Territory and avoids duplication of resources. This would require agreement of the State and/or Territory Governments where the nuclear plant could be located.

Nuclear power plant designs are assessed, approved and licensed by a nuclear regulator before construction. ARPANSA has for many years ably performed its role as Australia's federal nuclear regulator. With more resources and by drawing on international experience in regulating and licensing nuclear power reactors, ARPANSA can apply its experience and knowledge to also regulate nuclear power reactors.

As with the aircraft industry nuclear power plant designs are continually being improved based on the operating experience of current nuclear power plants. The most significant design improvements in both large scale Generation III and Small Modular Reactors (SMRs) is the introduction of safety features which enable these reactors to automatically shut down and remove decay heat using passive controls. This means that the reactors remain safe without external power supply or human intervention.

Small Modular Nuclear power plants are based on factory-built modules rated from 10 MWe to 250 MWe that are now undergoing regulatory assessment overseas. SMRs have advanced safety features, are designed to load-follow and their smaller size reduces the upfront capital

Recommendation

> **ANA recommends that the ARPANS Act be amended and that ARPANSA be the national regulator for licencing the siting, construction and operation of any nuclear power plant in Australia.**

Terms of Reference

C. Environmental impacts

Nuclear Generates Low Carbon Clean Electricity

Nuclear energy plays a key role in lowering carbon emissions from the power sector in many countries. The carbon emissions for the whole nuclear fuel cycle are very low and of the order of 40 g CO2/kWh. The low carbon emissions of nuclear power is similar to emissions from wind and hydro per unit of electricity produced [IPCC 2014] and slightly less than solar PV. This comparison assumes that methane from hydro is not significant and ignores the emissions from any storage or backup generators for wind and solar.

In 2018, nuclear power plants around the world produced 50% more clean electricity than wind and solar combined [IEA 2019a]. In the European Union and USA, nuclear produces more low carbon electricity than hydro [IEA 2019b].

Countries with nuclear energy are able to achieve very low carbon emissions from electricity generation. For example, nuclear supplied 72% of electricity in 2016 in France which had an electrical generation carbon emission intensity of 58 g CO_2/kWh compared to 440 g CO_2/kWh for its neighbour Germany which has a similar sized electricity grid and is closing nuclear plants. [EEA 2019]

Uranium is a very energy dense fuel. This means for example that while a 1000 MWe coal plant would consume about 2.6 million tonnes of coal per year, the equivalent nuclear plant would consume only 25 tonnes of uranium.

Partial refuelling takes place every 18 to 24 months. This means that a nuclear power plant releases very little air pollution and there are very limited truck movements to supply fuel. Most nuclear plant has an operating lifetime of up to 60 years.

Nuclear is a large-scale generator which can be a coal replacement technology. Both large scale nuclear power plants and the emerging small modular reactors would maximise the use of our existing power resources such as the grid, transport systems, cooling resources and most importantly the existing work forces. The construction and operation of nuclear power plants can help to ensure stable regional communities and local economies for many decades.

Nuclear power benefits the environmental by reducing carbon emissions and other air pollution.

A prerequisite for nuclear power is removal of the prohibition in the EPBC Act to allow an Environmental Impact Statement for a nuclear power plant to be assessed and the Minister to make a determination on environmental impact.

Terms of Reference

D & E. Energy Affordability, Reliability and Economic Feasibility

Over the period 2022 to 2050 approximately 20,000 MWe of baseload generating plant in Australia will need replacement and there is no national plan for this critical issue. A range of options generally based on variable renewable energy (VRE) has been widely promoted across the Australian community and media.

Appropriate technology and engineering excellence are crucial to ensuring lowest overall cost, technical standards and reliable operation. Poor choices for the existing and future electricity sector have already led to expensive mistakes that will bedevil many households, businesses and Australian prosperity as a nation for years to come.

Electricity sector generation asset replacement for Australia is a policy and planning issue currently being left to the market and impacted by subsidies such as the Large Scale Renewable Energy Target (LRET). Markets by their competitive nature are incidental to the national interest. The investment problem is driven by a liberalised market that provides no reliable long-term guarantee for return on capital investment for new base load generation. An energy only market where the only chance for plant utilisation and financial return is settled every half hour gives insufficient security or incentive to investors who may wish to provide capital for new dispatchable facilities. A capacity market is needed for economic security of energy supply.

Variable levels of solar and wind power operation will require quick start backup response, transmission augmentation, system quality management and long-term backup and/or storage. This results in additional system wide costs that must be included in electricity prices.

A range of energy generating mixes have been analysed with the Energy Power Consulting (EPC) model (https://epc.com.au/index.php/nem-model/). The EPC model is a cost model of the National Energy Market (NEM) using levelised cost of different technologies to dispatch generation in order of lowest marginal cost to maximise reliability. The model also calculates the “System Levelised Cost of Energy” (SLCOE) for the whole NEM power system including cost of storage and any extra transmission costs.

The EPC model uses load and generation data provided by the Australian Energy Market Operator for each period of 30 minutes over the year 2017. This represents 17,520 data sets analysed for the current and typical future system, winter/summer, day/night electricity load demand pattern using generation combinations available for the Australian electricity sector. This level of analysis picks up the real impact of intermittency of solar and wind generation and what is required to fix this problem.

The system engineering model first matches the actual load demand at each data point with a feasible generation combination to ensure all demand is met at all times. Some proposals are shown to be not operationally feasible. When balance is achieved the final generation mix is costed. The transmission, distribution and retail costs are added and a cost to the consumer is calculated.

The EPC model allows financial analysis over a range of discount rates to give an assessment of options for public and private funding.

A minimum cost is achieved by optimising the generation mix. The model mirrors the actual working of the Australian grid and current National Electricity Market. The EPC model does not analyse large scale demand management as this is an inappropriate high risk response to inherent system failure particularly for industrial consumers in a modern society.

Apart from nuclear energy, all costing data was taken from actual capital and operating values outlined in the AEMO Integrated System Plan 2018.

Nuclear Power Costs

Costing for the nuclear power option was based on information provided by South Korean government agencies during an intensive study tour of that country's nuclear engineering industry. After adjusting the Korean costing information for the labour rates and general civil engineering costs currently seen on local major projects in Australia, the overnight cost of 1 GWe nuclear plant was A$6200/kWe which was used in the EPC model.

This estimate of A$6200 (US$4861) for the overnight cost of nuclear is compared in Figure 1 with the overnight costs of recent Gen III+ nuclear power plants from the MIT study (MIT 2018, Table H.1). Figure 1 also shows the overnight cost of four first-of-a-kind nuclear power reactors being built in USA and Europe and recent builds in South Korea and UAE. A nuclear power reactor to be built in Australia will be of a design already built and operating overseas to avoid these first-of-a-kind costs and delays.

These costs are indicative and would need to be confirmed by firm proposals from nuclear vendors when there is real opportunity to consider adding nuclear power to the grid.

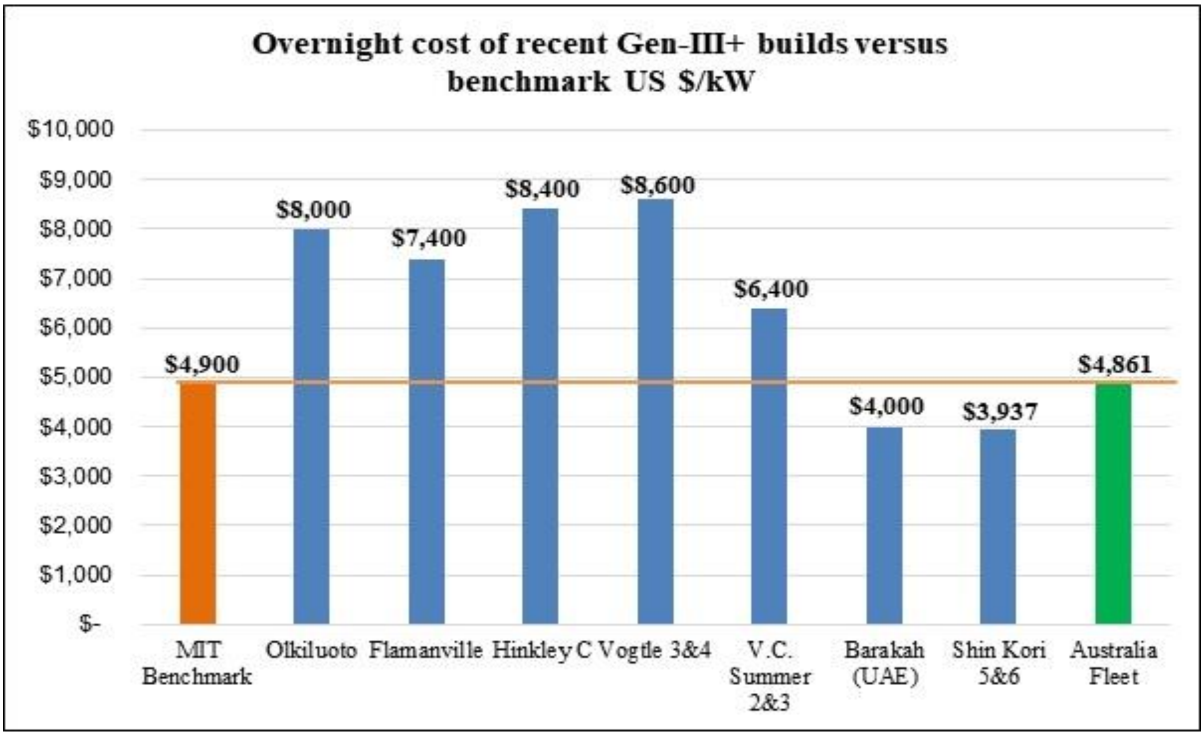


Figure 1 - Overnight Costs of recent nuclear power plants in 2017 $ (data from MIT 2018). The Australia estimate is based on data from South Korea adjusted for labour and civil engineering cost in Australia

System Levelised Costs of Electricity and Carbon Abatement with Nuclear Included

Figure 2 shows system levelised cost and carbon abatement achieved from a selection of generation options. The seven cases analysed cover the National Electricity Market as it currently operates together with a range of low emissions technologies using gas, renewable solar and wind and nuclear power. The cost of carbon dioxide emission abatement is also calculated.

While all load is met for each case to ensure comparable reliability, further analysis is required to ensure grid system quality standards and stability is maintained for the higher level nonsynchronous renewable options.

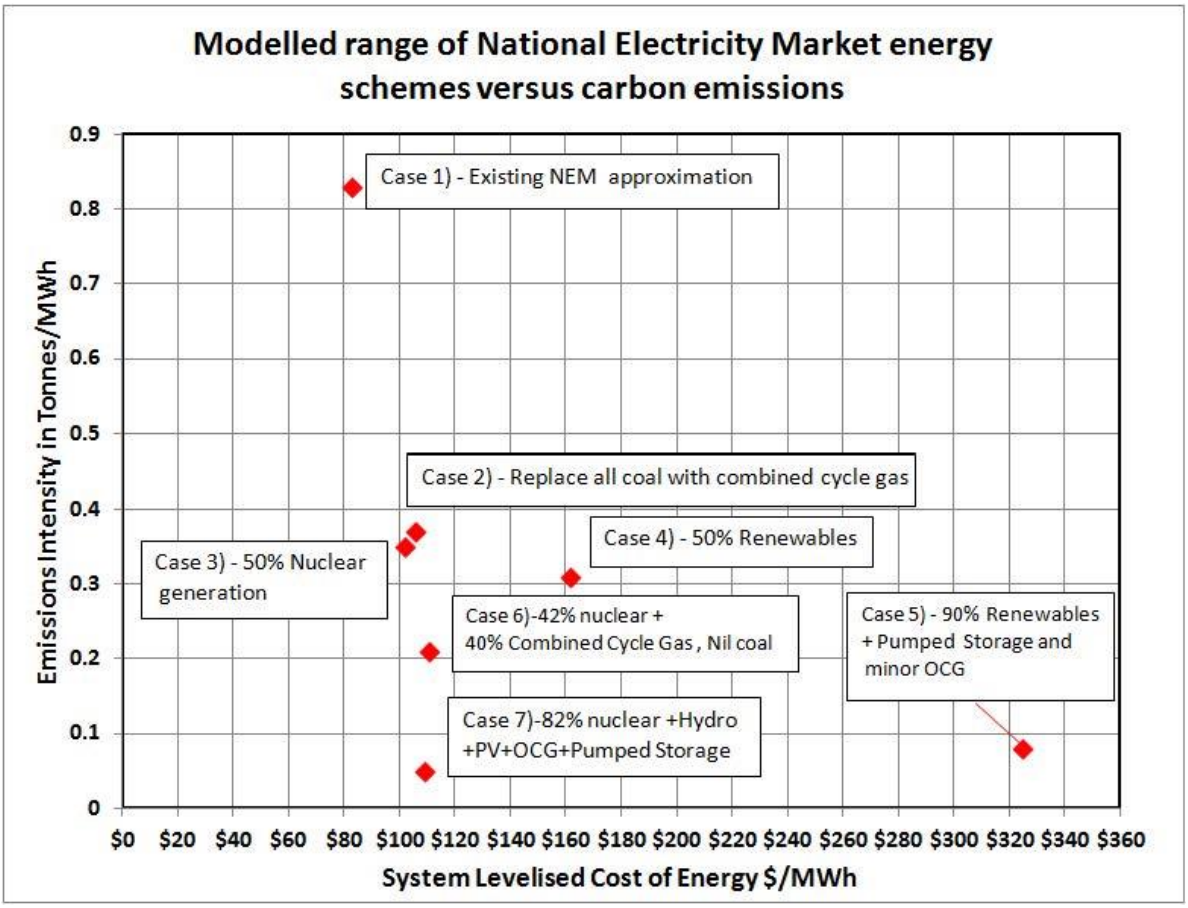


Figure 2 - Cost and Emission outcomes

Figure 3 shows that the retail electricity costs increase with the increasing percentages of renewable compared to nuclear electricity sourced in the NEM. Two key factors combine to progressively drive up the cost of solar and wind renewable generation options.

1. The intermittent output requires the provision of quick-start open cycle gas turbine capacity to augment existing hydroelectric capacity and new pumped storage capacity. The use of grid level electrical storage batteries is not currently a viable economic option.
2. As renewable generation increases the transmission costs also markedly increase. Lower capacity factors of renewable energy cause lower utilisation of the transmission network and therefore higher transmission costs. Analysis shows that benefits from wind and solar PV diversity across the NEM are quite marginal and come nowhere near providing a base load capability.

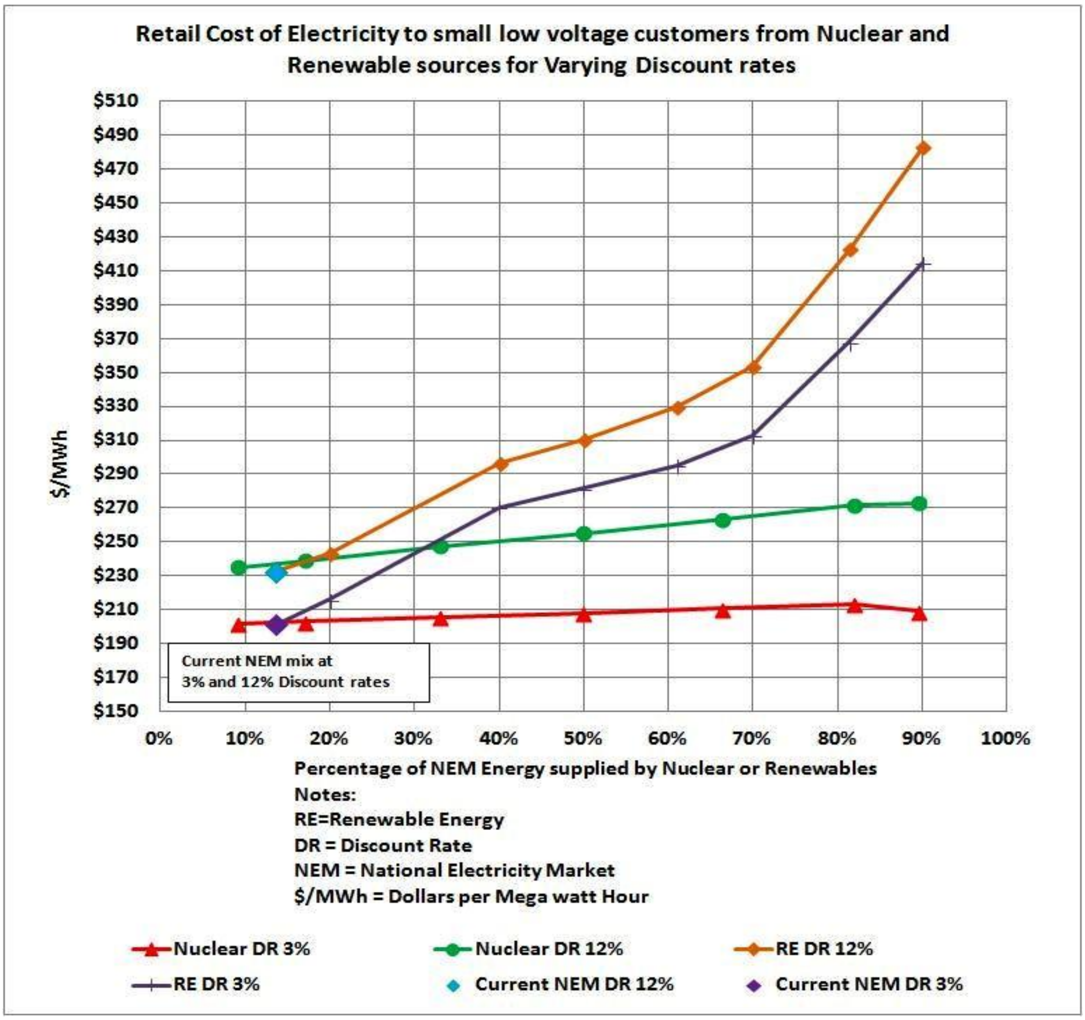


Figure 3 - Nuclear Energy Cost Competitiveness

The analysis reflects the actual intermittency across all Australian wind farm installations.

This investigation verifies that for deep carbon emission reductions nuclear power provides the most reliable cost-effective solution. This is verified by experience with very low emissions intensity and costs of electricity generation in France and Sweden compared to that in Germany where very large investments in VRE has been made. Figure 4 illustrates the relative cost of carbon dioxide abatement measures for increasing levels of renewable and nuclear power generation in the NEM

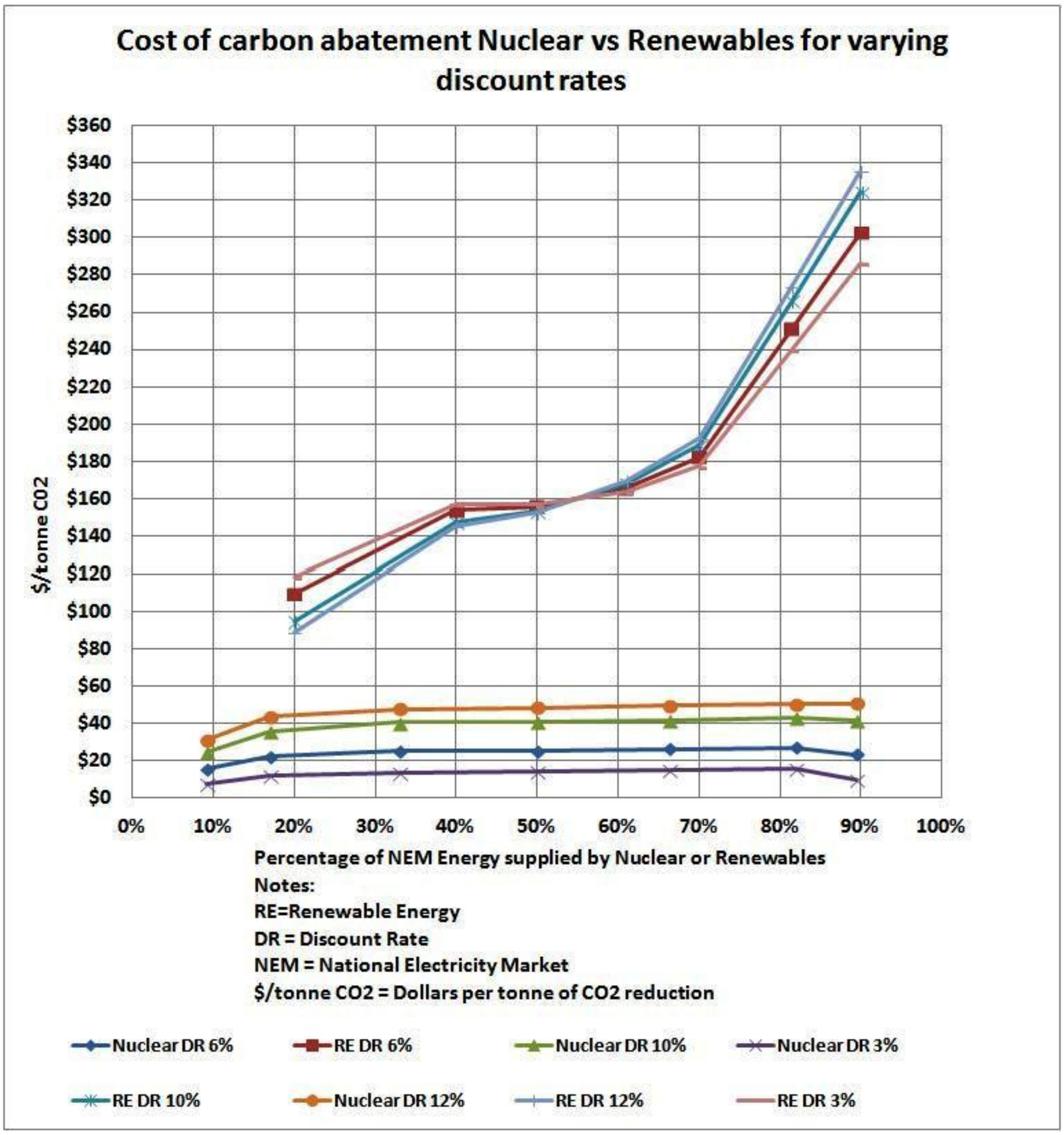
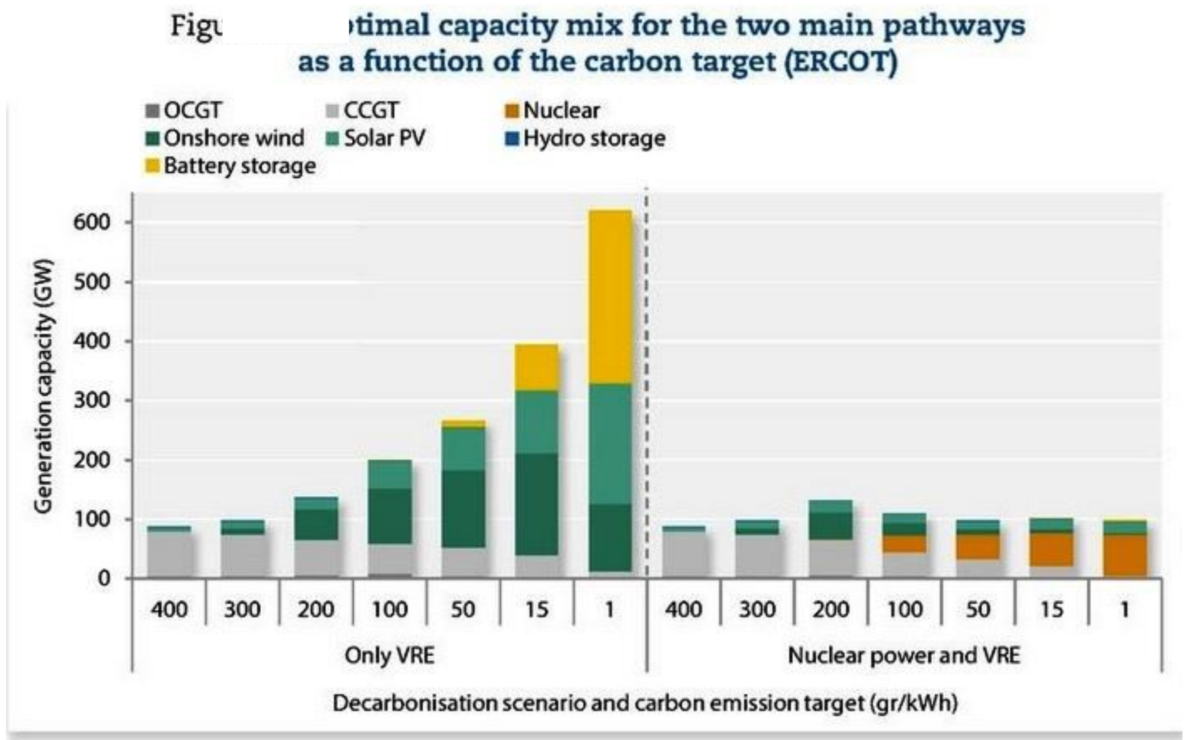


Figure 4 - Carbon Abatement costs comparison, Intermittent Renewables vs Nuclear Energy

OECD and MIT Modelling of Costs of Decarbonisation

A recent OECD report on the costs of decarbonisation for systems with high shares of nuclear and renewables highlighted the impact of the variability of wind and solar have on electricity system costs and the cost of the extra backup generators, costly transmission lines and excess capacity required [OECD 2019]. A Massachusetts Institute of Technology study analysed possible decarbonisation scenarios in the United States for different carbon emission targets and different sets of available low carbon power generation technologies (MIT 2018).

The results of MIT study of the capacity mix model for ERCOT (Electricity Reliability Council of Texas) with and without nuclear energy are shown in Figure 5. These results show a more than sixfold increase in generating capacity required to achieve a high level of decarbonisation when VREs are the sole option compared to options which include nuclear energy.



Source: Based on Sepulveda, 2016.

Figure 5- Impact of capacity mix with and without the inclusion of nuclear energy [Fig 17 of OCED 2019].

The cost implications for these various ERCOT emissions targets are shown in Figure 6. Because of their intrinsic variability, the overall system cost of adding large amounts of wind and solar are larger than the sum of their individual plant level costs.

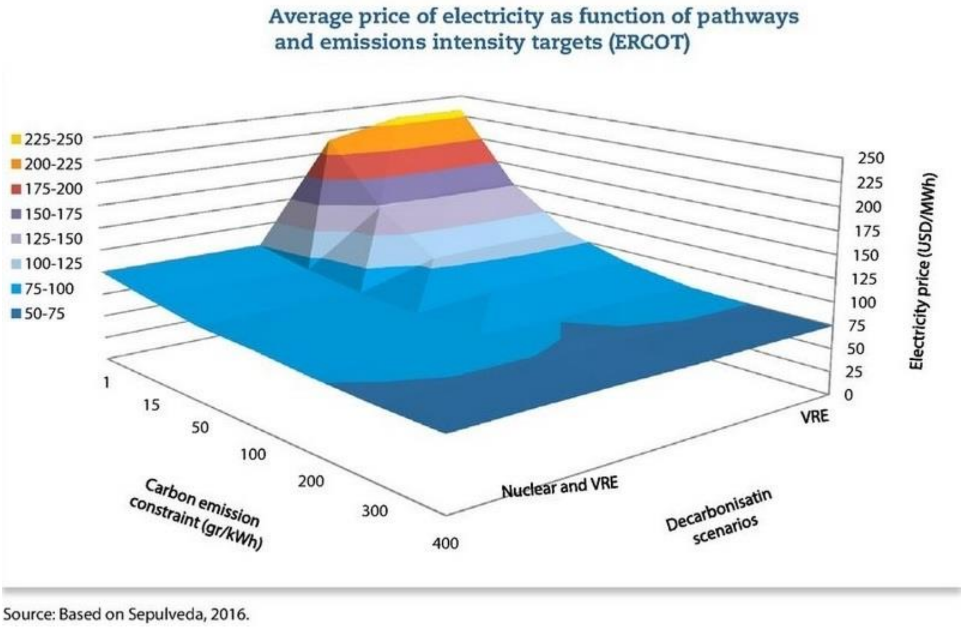


Figure 6 - Average Price of Electricity as a function of pathways and emissions intensity targets [Figure 15 of OECD 2019].

The results of the study carried out on the ERCOT system highlighted in the OECD 2019 analysis can be translated to many similar jurisdictions including that of the NEM. The trends observed when comparing a system that excludes nuclear energy with one that includes nuclear provide valuable insights.

In particular, the OECD 2019 study concludes that:

"... diversity of energy sources drives down total costs of energy in a low-carbon system, whereas taking options off the table – such as nuclear – creates extra costs to society".

It also indicates that:

"... the impacts of decarbonisation targets on the optimal investment policies are not linear and some targets may yield a share of a particular technology e.g. wind, that under a more stringent target may not be present in the optimal mix".

Decarbonisation policies should not be based on pre-specified shares of low-carbon resources in the mix, but rather the CO_2 reduction goals should be set. OECD recommends **a** CO_2 price (or a carbon market) as the optimal policy option for efficient decarbonisation; however, in the absence of CO_2 markets, support mechanisms should promote all types of low-carbon resources allowing for efficient adaptation among them [OECD 2019]. The OECD report supported by EPC modelling demonstrates that nuclear energy must be included in the options to achieve cost effective decarbonisation of Australia's energy system. Decarbonising our electricity system will need an optimum economic mix of all low carbon technologies.

Reliability

Figure 7 shows the increasing electricity price volatility on the NEM which is being driven by the reduction in the availability of dispatchable generation. This Figure shows the AEMO average monthly wholesale prices in $A/MWh between January 2013 and January 2019 on a state by state basis and increasing price volatility as well a steadily increasing wholesale price over this period.

These wholesale electricity prices can be compared with the LCOE of 20 GWe of nuclear energy capacity installed on the NEM spanning a range of discount rates (DR) between 3% and 10%. These values of $105/MWh, $79/MWh and $61/MWh are shown in the three horizontal dotted green lines in Figure 7. They were derived from the EPC model which also shows that 20 GW of nuclear capacity will provide 82% of the current annualized NEM demand of 190 TWh.

If this 20 GWe of nuclear capacity is integrated into a system containing solar PV, hydro, pumped storage in the form of Snowy Hydro 2.0 and a small amount of open cycle gas, the System Levelised Cost of Generation (SLCOE) determined by the EPC model is A$87/MWh and the emissions intensity of electricity generation is only 50g CO2/kWh. Nuclear energy is now economic as a stable, cost competitive, low carbon generating source on the NEM.

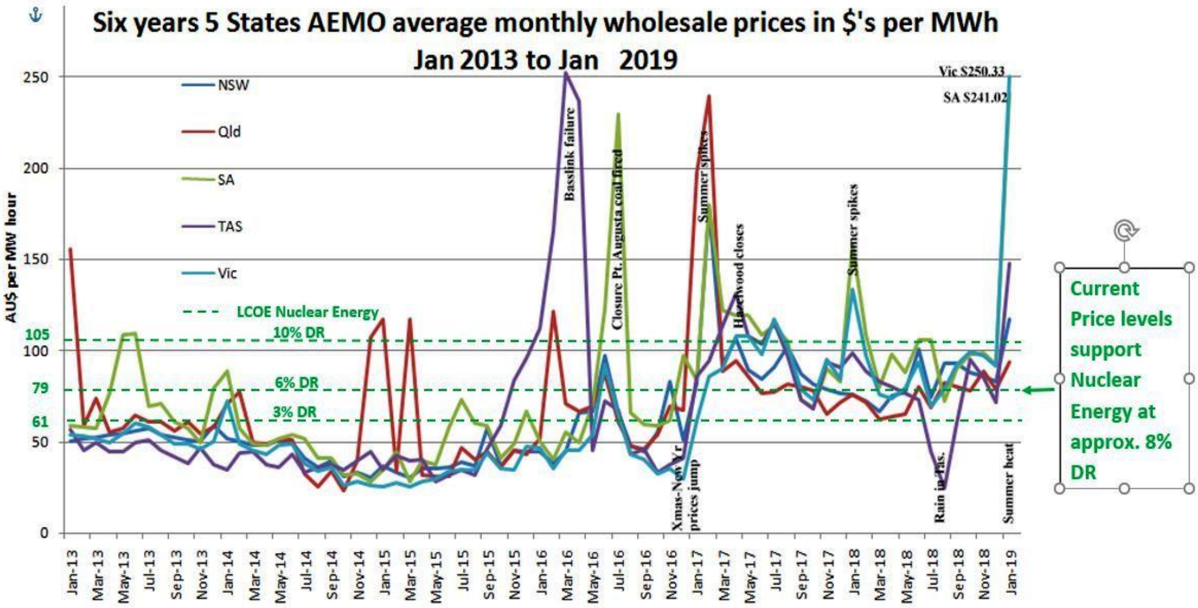


Figure 7. Competitiveness of Nuclear Energy on the NEM

The nuclear generation units suitable for installation in Australia could be the currently operating APR1000+ pressurised water reactors (PWR) designed and manufactured by South Korea, and NuScale's Small Modular Reactor (SMR) currently being licenced by the USNRC.

The APR1000+ units are an updated version of the OPR1000 unit which have a long history of development and world class reliable operation with over 10 units now in operation. Excellent local and export performance has seen recent 1400MWe versions of these units constructed on time and on budget; a factor of the utmost importance for investments of this nature. The larger units although more cost efficient are not suited to our current NEM grid but may be in the future. There is no other nuclear plant option currently available that provides the opportunity for early ordering together with the lowest overall risk profile and value for money.

Small modular reactor power plants hold out the promise of significant advantage in terms of siting options, installation time, economic cost and factory-based manufacture for the future. These units could be recommended for installation in Australia after costs are verified and significant operating experience has been gained in countries of origin. This is expected to be achieved within about 10 years.

Terms of Reference

F. Community Engagement

Nuclear energy is undergoing a resurgence of interest in Australia which is evident by inquiries happening at the Federal level and also within the States of New South Wales and Victoria. It is being driven primarily by escalating electricity prices and reliability of supply. Prior to Fukushima in 2011, there was a recovering level of confidence in the Australian community in support of nuclear power. That confidence suffered a setback following the disaster. However, there is a growing realisation that renewables alone cannot sustain Australia's electricity needs in the years ahead. While batteries can provide a few hours of backup, a reliable source of dispatchable power is needed.

The Australian Nuclear Association is seeing a significant ramp up in media engagement and community presentations on nuclear energy. The issues being raised by the public at these presentations are evolving. Two or three years ago they were reactor safety, radiation and cancer. These days a level of real interest exists in how nuclear energy can meet both our economic and environmental needs. Positivity is replacing anxiety.

Community engagement and stakeholder engagement is essential for the effective introduction of nuclear power to Australia. The prospect of a new industry and jobs can create a support base for nuclear power in regional location, particularly those near retiring coal plants. It is important to have open and honest communication with all stakeholders on the benefits and risks of a nuclear power plant.

Community engagement involves both the operator and the regulator. Responsibility for the safe operation of the facility lies with the operator and responsibility for ensuring the operator fulfils this role in safety and operational matters rest with the regulator.

The South Australian Royal Commission on the Nuclear Fuel Cycle (SA NFCRC 2016, Chapter 6) provide useful guidance on achieving social and community for a nuclear facility

Terms of Reference

G. Workforce Capability

Australia has technically capable workforce, evidenced in ANSTO, and a vocational and higher education sector that would rapidly train people needed in a nuclear industry. A new industry to replace the lost jobs in manufacturing and the coal power industry would be a welcome addition to the Australian economy.

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