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Senate Environment and Communications Legislation Committee Climate Change Bill 2022 Climate Change (Consequential Amendments) Bill 2022

SMR Nuclear Technology Pty Ltd (SMR-NT) is concerned that incomplete and out of date information about the cost of Small Modular Reactors (SMRs) is being provided to the government, particularly by the CSIRO GenCost 2021-22 Report issued July 2022.

Table B.8 of the report lists the data assumptions used for the overnight capital cost figures and the LCOE calculations.

The capital cost figures for 2021 Nuclear (SMR) are \$7,904/kW low assumption, \$16,773/kW high assumption. The \$16,773 is quoted by all the opponents of nuclear power in Australia to demonstrate that nuclear is too expensive to consider.

Where does CSIRO get the \$16,773 figure from, since this is higher than any figure in international publications?

You have to go back to the 2018 GenCost report to find the origin for this figure.

In 2018, CSIRO commissioned GHD to produce figures for Small Modular Reactors (SMRs) for their 2018 GenCost report. The GHD "Report for AEMO- AEMO costs and technical parameters review 9119715" table 57 lists a Gen IV reactor to be built in 2035 and quoted a cost of \$16,000/kW with the World Nuclear Association (WNA) as the source of the information.

This "Gen IV" was a concept design with no cost figures.

The WNA has always denied being the source for this figure. CSIRO has admitted that the basis of their figure was an International Energy Agency (IEA) report "Projected Costs of Electricity Generation 2015" that stated SMRs may be between 50% and 100% more than the cost of a large reactor. They took the cost of a large reactor as \$8,000/KW and multiplied by two to give the \$16,000/kW figure.

For the 2019/20 GenCost report, CSIRO contracted with Aurecon instead of GHD for the technical figures but did not ask for an update on nuclear technology so \$16,000/kW was again used, increased to \$16,304/kW. The figure was challenged by many organisations during the Federal and State nuclear inquiries. CSIRO were supplied with more accurate information but chose to ignore it. CSIRO admitted in the 2019/20 report that "GHD's source was unclear".

In 2020/21 CSIRO again used Aurecon but did not ask them to research the nuclear figures. The report listed \$16,487/kW.

During the consultations for the 2021/22 report, SMR-NT again contacted CSIRO and reminded them that the IEA had issued an updated "Projected Costs of Electricity Generation 2020". This takes a

more positive view of SMRs and instead of identifying a possible cost increase of 50%-100% over large nuclear it identified that SMR costs could be lower due to simplification, standardisation and modularisation.

The report also identifies that the cost of new nuclear is reducing:

“Electricity from new nuclear power plants has lower expected costs in the 2020 edition than in 2015”.

“Thanks to the experience gained with recent FOAK projects, new nuclear can enter in a phase of rapid learning in western OECD countries with near-term overnight costs reductions of 20% - 30% compared to today’s levels”.

The IEA report (table 3.4a) has overnight costs for new build (large) nuclear from low USD 2,157/kW (Korea) to USD 6,920/kW (Slovak Republic). The Slovak Republic figure is for the completion of a construction that started in 1985, was suspended in 1992 and restarted in 2009. It is a difficult completion of an old Russian design with western improvements and the cost is clearly not typical of new builds and it would be inappropriate to consider this as a high figure for new builds. Apart from this outlier, the highest cost is USD 4,250/kW (LWR built in the USA), and the average is USD 3,133/kW. At exchange rate of 0.7 (as used by CSIRO) the highest cost is AUD 6,071/kW.

The first real commercial deployment of an SMR is planned to be a NuScale plant at the INL site for UAMPS in operation before 2030. In November 2020, NuScale announced an increase of the module output from 60 MWe to 77 MWe. This lowers the estimated NOAK capital cost to USD 2,850/kW which is in line with the IEA report low costs. At an exchange rate of 0.7, this equates to AUD 4,071/kW and SMR-NT suggested this would be an appropriate low figure for their LCOE calculations. UAMPS maintain that the most important cost-associated figure for the project is the LCOE of USD 58/MWh.

Another SMR example is from General Electric Hitachi (GEH), a very experienced nuclear plant vendor. Their BWRX-300 SMR is designed to have an overnight cost of <USD 3,000/kW and an LCOE of <USD 65/MWh. This design is in the NRC licensing process.

The operations and maintenance cost assumptions in the GenCost report have also been higher than international data.

With regard to nuclear O&M costs, the GenCost 2021-22 report Apx Table B.8 Data assumptions for LCOE calculations has SMR O&M fixed \$200/kW, O&M variable \$5.3/MWh.

The US EIA Feb 2021 report (Levelised costs of New Generation Resources in the Annual Energy Outlook 2021) includes O&M figures for new nuclear build in 2026:
Variable O&M USD 2.38/MWh = AUD 3.4/MWh (rate 0.7)

SMRs are expected to have lower costs because of the simple systems and passive safety systems requiring less maintenance.

SMR-NT had previously supplied CSIRO with the NuScale O&M costs:

Fixed O&M USD 64/kW = AUD 91/kW (rate 0.7)

Variable O&M = 0

SMR-NT suggested that CSIRO should review their AUD 200/kW fixed O&M figure for new build down to AUD100/kW.

In summary, CSIRO is still using a “double the number you first thought of approach” based on an old report that they are aware is no longer relevant.

CSIRO has continued to use the \$16,000/kW basis for their overnight capital cost arguing that nothing has changed. What has changed is CSIRO’s knowledge that their figure is not supported by evidence from any project. This figure is also not supported by any cost analysis published by other organisations worldwide. The GenCost report would be expected to include the same high-quality costs for nuclear as been provided by Aurecon to CSIRO for other technologies in the report.

SMR-NT recommends that the government examines these cost figures.

SMR-NT also recommends that the government carefully consider the repowering of retiring coal-fired power stations with SMRs to utilize the existing valuable infrastructure and retain the skilled workforce and maintain local communities. The following part of this submission examines this in detail.

Australia has an opportunity to achieve better outcomes for communities and the climate.

SMR Nuclear Technology Pty Ltd (SMR-NT) is an independent Australian-owned specialist consulting company established in 2012.

SMR-NT was established to advise on and facilitate the siting, development and operation of safe nuclear power generation technologies, principally by Small Modular Reactors (SMRs).

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A Just Transition to Low-Emissions Technology - Repowering Coal-fired Power Stations in Australia with SMRs

June 2022 Update

The retirement of coal-fired power stations in the NEM provides an opportunity to re-use or re-purpose the infrastructure, retain jobs and maintain the life of local communities by repowering the sites with Small Modular Reactors.



Image: NuScale Power SMR, 12 x 77 MWe modules, 924 MWe total on an 18 hectare site.

EXECUTIVE SUMMARY

There are 47 remaining coal-fired power plants in the NEM on 16 sites and most of these will be retired before 2040. These sites have valuable infrastructure, particularly the transmission connections, that can be reused.

Also equally valuable is the highly skilled workforce.

These 16 sites could be repowered with Small Modular Reactors providing reliable, low emissions power just where it is needed.

Re-using the existing infrastructure makes the best use of the assets and reduces costs but, more importantly, retains jobs and keeps the local community alive.

This will facilitate a “Just Transition”.

There needs to be a shift from public acceptance to community involvement. Governments can assist in making this happen by providing finance to communities to enable them to explore all the options.

Australia has an opportunity to achieve better outcomes for communities and the climate.

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Abbreviations

AEMO	Australian Energy Market Operator, manages electricity and gas systems and markets across Australia
ANSTO	Australian Nuclear Science and Technology Organisation, Australia's nuclear research organisation
ARPANSA	Australian Radiation Protection and Nuclear Safety Agency, the Australian Federal nuclear regulator
BWR	Boiling Water Reactor, the second most common type of power reactor
NEM	National Electricity Market, the Australian east coast electricity system stretching from Queensland to South Australia, including Tasmania
NRC	Nuclear Regulatory Commission, the US nuclear regulator
OPAL	ANSTO's research reactor at Lucas Heights, produces medical and industrial isotopes, irradiates silicon for the semi-conductor industry and uses neutron beams for research. OPAL does not generate electricity.
PWR	Pressurised Water Reactor, the most common type of power reactor
SANFCRC	South Australia Nuclear Fuel Cycle Royal Commission, 2016 major study of the opportunities for South Australia in the nuclear fuel cycle including nuclear generation
SMR	Small Modular Reactor, the usual accepted definition is a power reactor with an output of up to 200 MWe

1. Coal-fired Power Stations in the NEM

There are 47 existing coal-fired units in the NEM on 16 sites, with a total generating capacity of 22,701 MW. Individual units range in output capacity from 280 MW to 744 MW. Many plants are old and will be retired, most will be shut down by 2040. AGL has already shutdown Liddell unit 3 and the remaining three units will be shut down in 2023. In addition to providing reliable, dispatchable generation, these plants also contribute to system inertia, stability and frequency control.

The main disadvantage of coal-fired power stations is their operating emissions. Typical subcritical black coal emissions are 940 kgCO₂-e/MWh and subcritical brown coal 1,140 kgCO₂-e/MWh¹. If the plants were replaced with the latest ultra-supercritical black coal this would only reduce the emissions to 700 kgCO₂-e/MWh which is still far too high. Any new coal-fired power stations would have to be equipped with carbon capture and storage and the cost of this would have to be assessed.

The only low emissions technology that is reliable, dispatchable and independent of the weather and provides the same system inertia and resilience as coal is nuclear power. For Australian conditions, SMRs would be a very suitable technology to repower coal-fired power station sites as coal-fired plants are retired.

Table 1: Existing coal-fired power plants in the NEM

Region	Name	Owner	Nameplate Capacity MW	Expected closure year and closure dates
NSW	Bayswater	AGL	BW01 660	2033
			BW02 660	2033
			BW03 660	2033
			BW04 685	2033
QLD	Callide B	CS Energy	B1 350	2028
			B2 350	2028
QLD	Callide C	Callide Energy + IG Power	CPP3 420 CPP4 420	2051* 2051*
NSW	Eraring	Origin Energy	ERO1 720	19/8/2025
			ERO2 720	19/8/2025
			ERO3 720	19/8/2025
			ERO4 720	19/8/2025
QLD	Gladstone	Gladstone PS Participants	GSTONE1 280	2035
			GSTONE2 280	2035
			GSTONE3 280	2035
			GSTONE4 280	2035
			GSTONE5 280	2035
			GSTONE6 280	2035
QLD	Kogan Creek	CS Energy	KPP1 744	2042
NSW	Liddell	AGL	LDO1 500	1/4/2023
			LDO2 500	1/4/2023
			LDO3 500	Shutdown 1/4/2022
			LDO4 500	1/4/2023

¹ Finkel report Appendix D

VIC	Loy Lang A	AGL	LYA1 560 LYA2 530 LYA3 560 LYA4 560	2045 2045 2045 2045
VIC	Loy Yang B	Gippsland Power	LOYB1 580 LOYB2 580	2047 2047
QLD	Millmerran	Millmerran Power Partners	MPP1 426 MPP2 426	2051 2051
NSW	Mt Piper	Energy Australia	MP1 730 MP2 660	2040 2040
QLD	Stanwell	Stanwell Corporation Ltd	STAN1 365 STAN2 365 STAN3 365 STAN4 365	2043 2044 2045 2046
QLD	Tarong	Stanwell Corporation Ltd	TARONG1 350 TARONG2 350 TARONG3 350 TARONG4 350	2036 2036 2037 2037
QLD	Tarong North	Stanwell Corporation Ltd	TNPS1 450	2037
NSW	Vales Point B	Delta Electricity	VP5 660 VP6 660	2029 2029
VIC	Yallourn W	Energy Australia	YWPS1 350 YWPS2 350 YWPS3 375 YWPS4 375	2028 2028 2028 2028

yellow highlight – closure date provided to AEMO

*Callide C – closure year not submitted to AEMO – 2051 based on 50 year life (commissioned 2001)

Source: AEMO NEM Generation Information May 2022

<https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/forecasting-and-planning-data/generation-information>

2. The Advantages of Reusing Existing Infrastructure

There are many advantages to repowering an existing electricity generation site:

- The transmission system was developed to make best use of these sites.
- Each site is already classified as an industrial site, avoiding some planning applications.
- Each site has already been assessed by the EPA for electricity generation. (There would have to be a new Environmental Impact Assessment for use as a nuclear facility).
- The local community is used to living near to the site. The site provides jobs in regional areas and brings significant economic benefits from the need for goods and services. The sites are located in rural areas where there are few other options for employment.
- The remaining coal-fired power plant sites in the NEM have large installed capacities ranging from 450 MW to 2,665 MW. They have strong transmission connections. The existing transmission connections are particularly valuable because:
 - They connect the existing large generators to load centres
 - New transmission lines are expensive. The Parsons Brinckerhoff report for the SANFCRC (2016) estimated \$344m for a 1,600 MW, 500kV, 50km transmission connection.

- The approval process for new HV transmission lines can be long and complex. There will always be some opposition to new HV transmission lines
- The HV switchyard on site is also a valuable asset.
- The existing coal-fired power plants have steam turbine generators with cooling water supplies under licence from the sea/lake/river for the turbine condensers. Most SMRs also use steam turbines and the existing cooling water supplies and licences can be used.
- The existing coal-fired power plants use demineralised water for boiler feed water. Most SMRs also use demineralised water
- Many existing buildings on the site can be reused, for example the administration building, stores and workshops
- The site firefighting system can be reused
- The existing transport links are also valuable. The roads would have already been upgraded to take heavy machinery. Some sites also have rail or barge access which is also very useful.

A study by NuScale estimated that, on average, US\$100m worth of infrastructure assets could be reused for a NuScale power plant.

Re-using the existing infrastructure makes the best use of the assets and reduces costs, but more importantly retains jobs and keeps the local community alive.

3. The Advantages of Repowering or Re-purposing Sites with SMRs

Nuclear is the best option to repower a coal site because it provides reliable power with zero operating emissions and can work in a system with wind and solar.

The low emissions technology options for repowering a coal-fired power plant are solar, wind, hydro and nuclear.

Solar has a very low energy density and requires a lot of flat land, for example Darlington Point is the largest solar farm connected to the NEM. It occupies 1,000 hectares and only produces 275MWac maximum output.

Wind farms have to be located in an area of good wind and require even more area than solar.

Hydro plants require a mountain type environment unlike a flat coal site.

Nuclear is the best option to repower a coal site. Nuclear is reliable with zero operating emissions. SMRs are the best nuclear option for Australia, because a modern 1,100 MW nuclear reactor would be too large a single unit for the Australian grid system. The largest single unit on the NEM is Kogan Creek 744MW.

SMRs have a high output capacity per land area. An SMR would fit easily on any power station site, for example a NuScale 12x77 MW (924 MW total) plant would occupy only 18 hectares. For comparison, the Liddell coal-fired power station site occupies 116 hectares and Vales Point B 88 hectares.

Bryden Wood has created a new digital platform for making the replacement of coal-fired boilers at existing power plants with advanced SMRs²

² Bryden Wood digital platform <https://www.world-nuclear-news.org/Articles/Digital-platform-launched-for-repowering-coal-plan>

Modern SMRs have become a game-changer for nuclear safety. The NuScale SMR does not require any operator action, back-up electrical supplies or water supplies to keep the reactor safe and would have survived even the Fukushima accident. The passive safety systems enables decay heat to be removed indefinitely without attention.

The enhanced safety characteristics of SMRs, such as smaller reactor cores, simpler systems and built-in passive safety features, mean that safety arrangements can be proportionate with these reduced risks. For example, the US NRC has a mandatory requirement for a 10-mile emergency planning zone (EPZ) around a large light-water reactor. This can be reduced to the site boundary for an SMR. This was confirmed when Tennessee Valley Authority (TVA) applied in 2016 for an Early Site Permit (ESP) for the potential use of its Clinch River site for an SMR. The NRC found that an SMR plant based on the NuScale design would meet the conditions for a site boundary EPZ.³ The NRC issued the ESP on 19 December 2019. An ESP certifies that a site is suitable for the construction of a nuclear power plant from the point of view of site safety, environmental impact and emergency planning.

This decision recognises the inherently lower risk profile of SMRs, simplifies the licensing and provides greater flexibility for siting. In particular this characteristic would allow an SMR to be sited on an existing coal-fired power station site.

Advantages of SMRs:

- Provide reliable, dispatchable generation independent of the weather
- Provide system inertia, resilience, frequency control and can load follow to work in a system with variable renewable energy
- Compact, factory built, transportable module reduces on-site construction time and reduces the risk of construction delays
- Lower initial capital cost than a large reactor and modules can be added as demand increases
- Zero operating emissions and low lifetime emissions comparable to wind and less than solar

4. Local Communities and the Need for a Just Transition

Replacing a coal-fired power station with an SMR would have an immediate effect on the health of the local community. There would be no more coal dust blown into their homes, no more breathing problems, no emissions of nitrous oxides, sulphur and heavy metals.

Community consultation, including with local Indigenous peoples, is crucial to any project and will also be a key factor in siting nuclear power plants. The local community must voluntarily agree to have their coal-fired power station site re-powered by an SMR. The agreement of the clear majority of local inhabitants is essential. This will require the local community to have access to factual information and independent experts to allow them to come to a knowledgeable decision. In this regard, the information available from the International Atomic Energy Agency (IAEA) will be very useful. In December 2021, the IAEA issued their latest guidance document “Stakeholder Engagement in Nuclear Programmes”.

³ NRC ESP for an SMR at TVA’s Clinch River site <https://www.nrc.gov/reactors/new-reactors/smr/clinch-river.html>

The Australian nuclear regulator, ARPANSA (Australian Radiation Protection and Nuclear Safety Agency) can also be asked to clarify any issues. In accordance with international best practice, ARPANSA is a completely independent agency, in the Federal Health Department, totally removed from industry.

Communities are looking for a “Just Transition” having devoted their lives to mining coal and operating coal-fired power stations. SMRs would provide this “Just Transition” for power station staff.

There needs to be a shift from public acceptance to public involvement.

5. Creating Jobs and Facilitating Economic Development

In addition to the existing valuable infrastructure, the other major site asset is the existing highly trained workforce.

A coal-fired power station consists of a coal-fired boiler to produce steam and a steam turbine generator which converts the steam into electricity.

An SMR has a nuclear reactor to produce steam. The rest of the plant is the same as a coal-fired power station. This means that if you are a turbine operator at a coal-fired power station you could easily transition to a job as a turbine operator at an SMR. The same transition applies to maintenance staff. Many systems are similar, including condensate and feed pumps, air compressors, cooling water pumps, water treatment plant, electrical and control systems.

Staff will need familiarisation with the new systems and some staff will require additional training to be licenced to operate the nuclear reactor and carry out maintenance on reactor systems.

This would be achieved with the support of universities and technical colleges, SMR vendor training and experience at operating nuclear power plants overseas. The use of simulators (as in the aircraft industry) is an important training tool. Most nuclear power plants have simulators for initial and on-going training.

It is essential that the operating staff are appointed at the same time as construction of the facility commences. This enables the future operating staff to see the plant as it is built and gain valuable experience by participating in commissioning. This is the practice in the UK, and was very successfully adopted for ANSTO’s new OPAL research reactor.

NuScale has issued a report on repurposing US coal plants including the transition of workers to similar positions.⁴

NuScale has assessed that a 12 module, 924 MW NuScale plant will employ 270 staff. This includes ~200 operations/maintenance/outage/technical staff. A large two-unit coal-fired power station would have around the same number of these staff, including around the same number of shift operations staff. NuScale estimate 45 operations staff will be required (5 shifts x 9).

Nuclear plants provide high quality, long-term, well-paid jobs. New SMRs have a design life of 60 years providing good long-term employment and career prospects.

⁴ <http://www.smrnuclear.com.au/wp-content/uploads/2021/04/nuscale-smr-technology-an-ideal-solution.pdf>

Table 2: List of coal plant positions with comparable NuScale SMR positions (table provided courtesy of NuScale Power)

Department	Coal Power Plant Position	NuScale Equivalent Position
Senior Management	Plant Manager	Plant Manager ¹
	Operations Manager	Operations Manager ^{1,2}
	Maintenance Manager	Maintenance Manager ¹
	Engineering Manager	Technical Services Director ^{1,2}
	Common Facilities Manager	Site Support Services Supervisor
Operations	Assistant Ops Manager	Shift Manager ²
	Shift Supervisor	Control Room Supervisor ²
	Control Room Operator	Reactor Operator ³
	Field Operator	Non-licensed Operator
Outage Planning	Outage Manager	Generation & Planning Manager ¹
	Planner	Planner
Maintenance Planning	Maintenance Supervisor	Maintenance Supervisor
	Foreman	Work Control Lead
	Planner	Planner
	Engineering Technician	Work Control Scheduler
Maintenance Planning	Boilermaker	Mechanic
	Steam Fitter	Mechanic
	Mechanic	Mechanic
	I&C Technician	I&C Technician
	Electrician	Electrician
	Heavy Equipment Operator	Site Support Craftsman
	Auto Mechanic	Mechanic
	Labor Foreman	Site Support Craftsman
	Laborers	Site Support Craftsman
	Metal Fabricator/Welder	Site Support Craftsman
Tool Room Specialist	Tool Crib Attendant	
Engineering	Thermal Station Engineer	Design Engineer
	System Engineer	System Engineer
	Site Project Engineer	Component Engineer
	Shift Engineer	Staff Technical Advisor
	Project Manager	Supply Chain Specialist
Environmental	Environmental Board Operator	Radwaste Operator
	Environmental Operator	Non-licensed Operator
	Plant Chemist	Chemistry Technician ⁴
Coal Yard and Railroad	Coal Yard Specialist	Site Support Craftsman
	Coal Handler	Site Support Craftsman
	Railroad Specialist	Site Support Craftsman
	Railroad Train Operator	Site Support Craftsman
Security	Security Guard	Nuclear Security Officer

Notes for table 2 (as applicable in the USA):

1. Nuclear power plant experience requirement of 4 years
2. Senior reactor operator experience required
3. Reactor operator licence required
4. Limited to secondary and auxiliary water chemical analyses

The first NuScale SMR is planned to be sited near Idaho Falls, USA. The Idaho Department of Labor has forecast that the SMR will generate 12,800 local jobs during construction and 1,500 during operations.

The 1,000 direct construction jobs would create or support an additional 11,800 jobs through ‘inter-industry’ trade and local services for the new workforce. NuScale expects direct construction jobs to peak at 1,100 employees and this would last for much of the three-year site build.

The new plant will also support long term employment in Idaho Falls. NuScale expects the plant to directly employ 270 workers when it is online and the Department of Labor expects this will support 1,500 local jobs, equating to annual revenues of US\$389 million for local industry in this regional area.

Trade unions recognise the value of the high-quality jobs that nuclear power can provide Australians.

Trade unions are amongst the strongest supporters of nuclear energy in countries that already have operating nuclear power plants. Unions in Australia are already recognising the merits of SMRs in replacing existing dispatchable generation. Coal plant workers and their communities demand a ‘Just Transition’ of their industry, a transition where their livelihoods are not unwittingly destroyed by the rush to reduce emissions.

Social costs of job losses from the closure of coal plants and mines in regions such as the Latrobe and Hunter Valleys will be immense. Many claim that renewables can provide a transition in employment for coal plant workers. However, jobs in wind and solar are often in a different region and do not provide the same level of sustained income as coal jobs. SMRs utilise similar equipment to coal plants on the secondary side of the plant and therefore can transfer jobs more directly and at the same location.

The Mining & Energy Union Victoria (a Division of the CFMMEU) has also stated concern about a renewables-only approach to emission reduction because it would lead to ‘major blackouts, unaffordable electricity and the future economic shutdown of Victoria’s industry; resulting in massive job losses and citizen wealth decline.’ Australia already has the skilled people needed for a nuclear power industry but a 7-year lead time will be required to build SMR replacements for Australia’s aging coal power plants. Therefore, the green light needs to be given sooner rather than later.⁵

An expanded domestic nuclear industry with nuclear power generation would give many communities across Australia the opportunity for economic development. All sites should develop an Indigenous employment strategy including training, mentoring, apprenticeship support for local students, and incorporating unique cultural skills, especially in environmental management.

In 2019, Colorado, USA, established an “Office of Just Transition” specifically to help coal communities move into new, well-paid jobs⁶.

⁵ https://www.energypolicyinstitute.com.au/images/2-20__Geoff_Dyke_PP.pdf

⁶ About the Office of Just Transition,” Colorado Department of Labor and Employment, <https://cdle.colorado.gov/offices/the-office-of-just-transition/about-the-office-of-just-transition>

6. Examples of SMRs Suitable for Repowering Coal Sites

Table 3: SMRs suitable for repowering coal sites in Australia

Vendor/country	Reactor	Module/plant size MW	Status
NuScale USA	VOYGR	77 MW 4 module 308 MW 6 module 462 MW 12 module 924 MW	US NRC GDA Funding from US DOE First deployment for UAMPS at INL. Site fieldwork completed Feb 2022, first module operating 2029. Several countries evaluating.
GE-Hitachi USA	BWRX-300	300 MW	Topical reports being assessed by NRC. Site preparations started for deployment at Ontario Power Generation (OPG) Darlington site, Canada. Tennessee Valley Authority(TVA) already has an early site permit (ESP) for Clinch River site, USA – now preparing construction licence application. Agreements with several countries.
Holtec USA	SMR-160	160 MW	Topical reports to NRC Czech Republic evaluating
Rolls Royce SMR UK	Rolls-Royce SMR	440 MW	Preparing for UK GDA application Funding from UK Government. Several sites in UK being assessed. MOUs with several countries
Terrestrial Energy Canada	IMSR (Integrated Molten Salt Reactor)	195 MW 2 module 390 MW	CNSC Phase 2 review expected complete 2022. Extensive supply agreements. First deployment expected in Canada.
Moltex Energy UK/Canada	SSR-W300	150 MW 2 module 300 MW	CNSC Phase 1 VDR completed Canadian Government investment Proposed deployment at New Brunswick Power Point Lepreau site
Kairos Power USA	KP-FHR (Triso fuel, fluoride salt cooled)	140 MW	Topical reports being assessed by NRC UD DOE awards Plan to deploy a test version at East Tennessee Technology Park in 2023
Terrapower + GEH USA	Sodium SFR with molten salt energy storage	345 MW + storage boost to 500 MW	First deployment at retiring Naughton coal-fired power plant, Kemmerer, Wyoming. Operating by 2028.
X-Energy USA	Xe-100	80 MW 4 module 320 MW	DOE funding to demonstrate a 4-module plant at Energy Northwest’s Columbia nuclear plant

Figure 1: NuScale Power SMR



Image: NuScale Power SMR, 12 x 77 MWe modules, 924 MWe total on an 13 hectare site. US Nuclear Regulatory Commission (NRC) Final Safety Evaluation Report issued in August 2020 - first SMR to achieve NRC design approval.

Figure 2: GE Hitachi BWRX-300 SMR (300 MWe) December 2019 started regulatory process with NRC

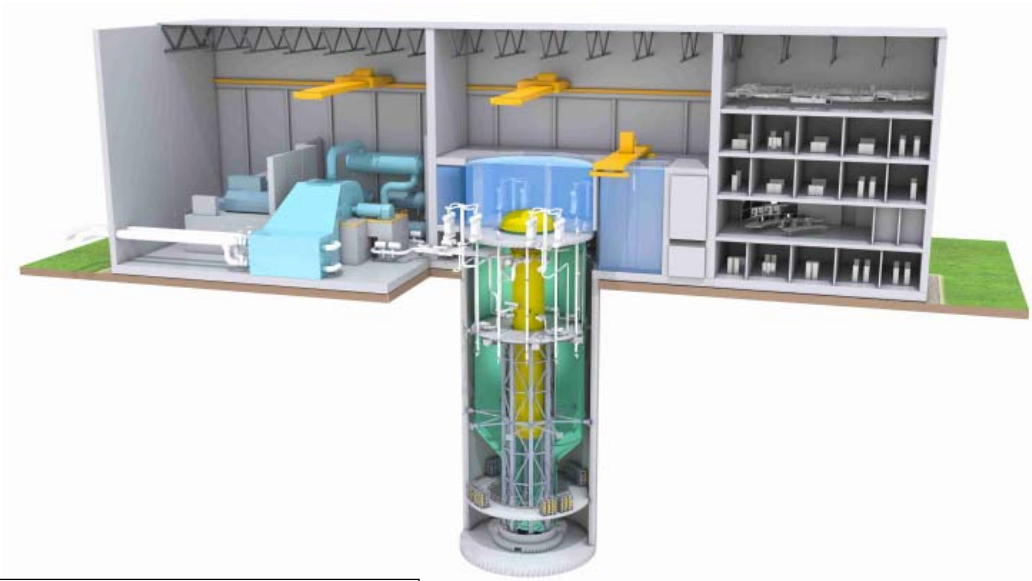


Image: GE Hitachi Nuclear Energy

7. Cost of SMRs

NuScale estimate⁷ the overnight capital cost of their 12 module 924 MW plant will be US\$2,850/kW installed capacity for the Nth of a kind plant. This would make it the least cost reliable technology in Australia.

The modular approach, factory manufacture and standardised and simplified design results in a significant capital cost reduction compared to large reactors. The simplified design also leads to lower operations and maintenance costs.

GE Hitachi is targeting US\$2,250/kW installed capacity⁸ for the overnight capital cost of their BWRX-300 SMR.

8. International Projects for Repowering Coal Sites

Terrapower (USA), backed by Bill Gates, is planning to deploy its Natrium reactor at the Naughton retiring coal-fired plant at Kemmerer, Wyoming owned by Rocky Mountain Power, a subsidiary of PacifiCorp⁹. The site was chosen following an extensive evaluation process and community meetings. Natrium is a 345 MW sodium cooled fast reactor combined with a molten salt storage that boosts the output to 500 MW when required, enabling the plant to follow daily demand changes and work with variable renewable generation. Terrapower estimates the plant would operate with 250 permanent staff and the existing 230 Rocky Mountain Power staff could transfer to the nuclear plant.

Wyoming currently generates 90% of its electricity from fossil fuels. The two-remaining coal-fired plants on the Naughton site are due to retire in 2025. Terrapower aims to submit a construction permit application to the NRC in 2023.

Poland, like Australia, is heavily dependent on coal-fired generation. In December 2021 GE Hitachi Nuclear Energy (GEH), BWXT Canada and Poland's Synthos Green Energy (SGE) signed a Letter of Intent to cooperate in deploying BWRX-300 SMRs in Poland. SGE plan to deploy at least 10 BWRX-300 SMRs in Poland by the early 2030s with the first to be operational in 2029.¹⁰

⁷ <http://www.smrnuclear.com.au/wp-content/uploads/2021/04/nuscale-smr-technology-an-ideal-solution.pdf>

⁸ https://nuclear.gewater.com/content/dam/gewater-nuclear/global/en_US/documents/product-fact-sheets/GE%20Hitachi%20BWRX-300%20Fact%20sheet.pdf

⁹ <https://www.world-nuclear-news.org/Articles/Wyoming-site-chosen-for-Natrium-plant>

¹⁰ <https://www.world-nuclear-news.org/Articles/Collaboration-for-Polish-deployment-of-BWRX-300>

9. Utility Owners in Australia with International Nuclear Experience

Whilst nuclear power continues to be prohibited by two Federal and some State laws in Australia, there will be little enthusiasm to explore opportunities for the deployment of SMRs.

When the bans are removed and the market conditions are suitable, there will be an interest in SMR deployment by overseas companies, as there has been by overseas companies to deploy solar and wind in Australia. The market will need to recognise the value of SMR low emissions generation, both for its reliable electricity production and for its contribution to system inertial and stability.

Experience worldwide is finding that net zero by 2050 will be more difficult and costly without reliable, low-emissions nuclear. Also repowering retiring coal enables a just transition for communities and would demonstrate a caring and efficient government with a long-term vision.

There are some utility owners in Australia with nuclear experience who will no doubt become interested, particularly those with existing power station sites.

Table 4: Utility Owners in Australia with Nuclear Experience

Company	Australia activities	Owner	Nuclear
Energy Australia	Electricity generation, electricity and gas retailer	Wholly owned by China Light and Power	CLP is part owner of the Daya Bay nuclear power plant in Guangdong, China
ENGIE	Owens and operates wind and gas-fired generation plant	French multinational energy utility	Pioneer in nuclear energy for 55 years in Europe. Operates 7 nuclear reactors in Belgium.

10. Conclusions

Low-Emissions Generation Technology selection requires ‘horses for courses’ – that is, it requires the selection of technologies that will enable the reusing or repurposing of existing infrastructure. The selection process cannot be conducted by a desk-top study and requires the participation of affected communities.

This report elaborates on the merits of selecting the most suitable low-emissions generation technology to replace coal-fired power plants as they may be retired in Australia over the coming two decades. The report follows an earlier report by SMR Nuclear Technology Pty Ltd in August 2021 ‘The Case for SMRs in Australia’¹¹.

The report advocates to the Australian government not to search for, or attempt to select, the ‘best’ low-emissions generation technology on paper but to instigate a process to support those technologies that are suitable for repowering existing power station sites, retaining jobs, preserving local and regional communities and providing for a Just Transition for all Australians.

¹¹ http://www.smrnuclear.com.au/wp-content/uploads/2021/07/The-case-for-SMRs-in-Australia_Aug2021.pdf

There needs to be a shift from public acceptance to community involvement. Governments can assist in making this happen by providing finance to communities to enable them to explore all the options.

Australia has an opportunity to achieve better outcomes for communities and the climate.

General References

Good Energy Collective “Opportunities for coal communities through nuclear energy – an early look”
Dec 2021 <https://www.goodenergycollective.org/policy/coal-repowering>

NuScale SMR Technology – An Ideal Solution for Repurposing US Coal Plant Infrastructure and Revitalizing Communities, 2021 <http://www.smrnuclear.com.au/wp-content/uploads/2021/04/nuscale-smr-technology-an-ideal-solution.pdf>

Minerals Council of Australia “SMRs small modular reactors in the Australian Context’ Dr Ben Heard, October 2021
<https://www.minerals.org.au/sites/default/files/Small%20Modular%20Reactors%20in%20the%20Australian%20Context%202021.pdf>

SMR Nuclear Technology Pty Ltd “The Case for SMRs in Australia”, August 2021,
http://www.smrnuclear.com.au/wp-content/uploads/2021/07/The-case-for-SMRs-in-Australia_Aug2021.pdf

University of Michigan “Fastest Path to Zero Initiative” <https://fastestpathtozero.umich.edu/>
(technology neutral tools to aid community-based decision making)

IAEA Stakeholder Engagement in Nuclear Programmes, Nuclear Energy Series NG-G-5.1
<https://www.iaea.org/publications/14885/stakeholder-engagement-in-nuclear-programmes>

What would be required for nuclear energy plants to be operating in Australia from the 2020’s
University of Queensland <http://www.smrnuclear.com.au/wp-content/uploads/2022/01/WhatWouldBeRequired-FINAL-002.pdf>

SMR Nuclear Technology Pty Ltd (SMR-NT) is an independent Australian-owned specialist consulting company established in 2012.

SMR-NT was established to advise on and facilitate the siting, development and operation of safe nuclear power generation technologies, principally by Small Modular Reactors (SMRs).

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Appendix A: Siting Considerations for Nuclear Power Plants

Although an SMR would physically fit on any coal-fired power station site in the NEM, any site would have to be assessed for its acceptance for a nuclear power reactor. The IAEA has issued the *2019 Specific Safety Requirements SSR-1 Site Evaluation for Nuclear Installations*¹². It is an international safety requirement that the site is evaluated such that the site-specific hazards and site related safety characteristics are adequately taken into account. This includes evaluation of external hazards including seismic, flooding, geotechnical characteristics and the evaluation of potential effects of the nuclear installation in the region.

In addition, *Specific Safety Guide SSG-35 Site Survey and Site Selection for Nuclear Installations*¹³ provides recommendations and guidance in meeting the safety requirements of SSR-1.

The ARPANSA Regulatory Guide – Siting of Controlled Facilities (ARPANSA-GDE-1756WEB)¹⁴ makes reference to the IAEA documents and advises of the issues to be addressed by an applicant when applying for a licence under the ARPANS Act to prepare a site in Australia for a controlled facility. Currently the ARPANS Act only allows for the licencing of a Research Reactor in Australia. Licensing of a power reactor is prohibited by the ARPANSA Act and the EPBC Act. These prohibitions must be removed to allow Australia to make use of all available low emissions technologies.

The enhanced safety characteristics of SMRs, such as smaller reactor cores, simpler systems and built-in passive safety features, means that safety arrangements can be proportionate with these reduced risks. For example, the US NRC has a mandatory requirement for a 10-mile emergency planning zone (EPZ) around a large light-water reactor. This can be reduced to the site boundary for an SMR. This was confirmed when Tennessee Valley Authority (TVA) applied in 2016 for an Early Site Permit (ESP) for the potential use of its Clinch River site for an SMR. The NRC found that an SMR plant based on the NuScale design would meet the conditions for a site boundary EPZ.¹⁵ The NRC issued the ESP on 19 December 2019. An ESP certifies that a site is suitable for the construction of a nuclear power plant from the point of view of site safety, environmental impact and emergency planning.

¹² SSR-1 <https://www.iaea.org/publications/13413/site-evaluation-for-nuclear-installations>

¹³ SSG-35 <https://www.iaea.org/publications/10696/site-survey-and-site-selection-for-nuclear-installations>

¹⁴ <https://www.arpansa.gov.au/regulation-and-licensing/licensing/information-for-licence-holders/regulatory-guides/regulatory-guide-siting-controlled-facilities>

¹⁵ NRC ESP for an SMR at TVA's Clinch River site <https://www.nrc.gov/reactors/new-reactors/smr/clinch-river.html>