World Nuclear Association submission to CSIRO - GenCost 2023-24 public consultation

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Exclusion of large nuclear reactors

Large-scale nuclear is excluded from the draft report. The justification for this is provided on page 17:

"GenCost has been advised by stakeholders that small modular reactors are the appropriate size nuclear technology for Australia. Australia's state electricity grids are relatively small compared to the rest of the world and planned maintenance or unplanned outages of large scale nuclear generation would create a large contingent event of a gigawatt or more that other plant would find challenging to address. In the present system, it would take two or more generation units to provide that role. As such, large-scale nuclear plants which are currently lower cost than nuclear SMR, may not be an option for Australia, unless rolled out as a fleet that supports each other - which represents a much larger investment proposition."

The reasoning provided in this paragraph for the exclusion of large-scale nuclear does not stand up to scrutiny. There are several key points to be made:

1. Small grids and contingency events

Australia's largest power grid already hosts large-scale generation units. There are 21 GW of 700MW+ coal capacity across Australia's National Electricity Market (NEM), which physically connects the country's eastern and southern states and territories. Four coal power plants in operation in the NEM today have an individual capacity larger than 1.5 GW[i]. The states comprising the NEM do not simply host these units, they *rely* on them to provide stable and predictable electricity supply.

About 175 TWh is supplied annually through the NEM to about 23 million customers from about 80 GW of generating capacity[ii]. Modern large-scale nuclear reactors are typically about 1 GW capacity and provide about 8 TWh of electricity annually when operated at typical 80-90% capacity factors. At present, therefore, a single gigawatt-scale reactor would provide less than 5% of the electricity supplied through the NEM. There are a total of 12 countries[1] that consume less than 175 TWh of electricity annually that have operating or under construction large-scale nuclear reactors.

AEMO's Draft 2024 Integrated System Plan (ISP)[iii] anticipates changes in Australia's electricity demand, supply and distribution and generation infrastructure that would further support the appropriateness of large-scale nuclear generation units. Specifically:

- Electricity consumption across NEM will rise by 108% by 2050. In that scenario, a single large nuclear unit would supply less than 2% of the NEM's electricity in 2050.
- 90% of the country's coal capacity will be retired by 2038 in the "most likely future scenario".

Clearly in this context – i.e. the near-term retirement of much of the country's firm capacity and the anticipation that electricity demand will rise significantly – large-scale nuclear is a technology that is worthy of consideration in any broad assessment of electricity generation options. It is also noteworthy that the large-scale build out of variable renewable energy anticipated in AEMO's ISP is predicated on an enormous investment in improving and expanding connections across the NEM and building 15-33 GW of natural gas capacity as backup. As the capacity and interconnectivity of the grid grows, so will its ability to respond to any loss of supply contingency event.

2. Grid inertia

It is unacknowledged in the draft report text that large-scale nuclear units would make a significant *contribution* to grid stability and reliability through the provision of rotational inertia. With the near-term

[1] *Egypt, Ukraine, Pakistan, Sweden, United Arab Emirates, Argentina, Netherlands, Finland, Belgium, Bangladesh, Czech Republic, Switzerland.*

retirement of the country's coal capacity, there will be a need for new synchronous generators capable of providing kinetic energy to the grid in loss of supply events to slow down the rate of frequency decline. If new synchronous capacity is not added, the ability of Australia's grid systems to restore to target frequency levels after a loss of power incident will be impacted, thus making them less robust[iv].

3. **"As such, large-scale nuclear plants… may not be an option for Australia, unless rolled out as a fleet that supports each other - which represents a much larger investment proposition."**

   This language is puzzling. The stated purpose and scope of the GenCost report is to "…provide an objective annual benchmark on cost projections…" It cannot achieve that purpose if it proposes investments and / or assumes a cap on the potential contribution of any given technology.

   In any case, as it was just discussed above, individual large nuclear power plants have the potential to significantly contribute to the Australian electricity system.

Small modular reactors – assumptions

Capital costs

The CSIRO report states that the capital costs of technologies provided are overnight costs, but this is not the case for SMRs. The capital cost assigned to SMRs of 31,100 AUD/kW is stated to have been derived from a published cost estimate from the UAMPS Carbon Free Power Project (CFPP) of USD 9.3 billion[v] data. This figure represents the total cost of acquisition and construction, including financing, while the net cost of acquisition and construction for the UAMPS Carbon Free Power Project (CFPP) is estimated as USD 5.1 billion. Therefore, by including financing costs for SMR, the CSIRO report significantly overestimates SMR capital cost, and results in an unequitable comparison with other technologies.

Given that the cost of SMRs remains speculative (relative to commercially proven large-scale nuclear), it is nonsensical to assume a single data point from one proposed project of one particular SMR technology that was cancelled for economic reasons as representative of the of whole range of SMR technologies and projects currently under development and of the potential deployment model. There is no persuasive justification given in the draft report for this approach considering that a number of commercial SMR projects are in development in several countries.

The report provides a range of SMR cost estimates in Figure 0-3. One of the figures quoted is a 2019 estimate from the US Energy Information Administration (EIA). Since the draft report was published, EIA has updated its capital cost estimates for different electricity generation options. The EIA 2024 report[vi] on Capital Cost for Electric Power Generating Technologies for SMR is derived from a plant of 6 x 80 MW Small Modular Reactor units which is similar to the UAMPS Carbon Free Power Project (CFPP) with an estimated total capital cost USD 4.3 billions, equivalent to a cost of 8,936 USD/kW net. This converts to 13,000-13,500 AUD/kW.

The EIA 2024 report also provides cost estimates for large scale nuclear reactors, based on 2 x AP1000, 2156 MW, the total estimated capital cost is USD 16.95 billion or 7,861 USD/kW net. The IEA World Energy Outlook 2023 uses capital costs for nuclear energy of 5,000 USD/kW for deployment in US.

Levelized cost of electricity (LCOE)

The report assumes an economic life for nuclear SMRs of 30 years, which is pessimistic and leads to over estimation of the LCOE. This is considerably lower than what is assumed in other similar reports; i.e the IEA assumes nuclear power plant operational life of 60 years[vii], and Lazard assumes 40 years[viii]. Most water cooled SMRs considered for near term deployment have design lives of 60 years. The operational life of SMRs could be further extended beyond 60 years, like several current large scale nuclear power plants whose licenses have been extended to operate for 80 years[ix]. Over two-thirds of electricity generated from nuclear energy in 2022 was from plants more than 30 years old[x].

In the high (renewable share) case, the CSIRO report' assumptions of the significant overbuild of variable renewable capacity combined with preferential dispatch for renewables results in all technologies operating at reduced utilization. The reduced capacity factors across all technologies in the high case are a cost imposed on the system (and therefore consumers) in order to accommodate high shares of variable renewable capacity. It is misleading to present a cost range for nuclear energy (and other dispatchable technologies) without clearly disclosing that it is simply a function of capacity factor, which in turn is a function of variable renewable penetration.

Continued use of LCOE

LCOE was developed to compare costs of dispatchable baseload, such as nuclear and coal plants, with similar capacity factors and generation attributes. It is a measure of the cost of a marginal MWh. However, LCOE does not provide a suitable metric when comparing intermittent renewable generation with dispatchable generation.

The report details some of the limitations of LCOE as a calculated cost metric, but presents LCOE estimates nevertheless. There is some attempt to account for the system costs imposed by variable renewable energy, but this is incomplete[xi, xii]. Continued use of LCOE as a suitable tool for comparing variable and dispatchable electricity supply it will lead to bad policy making.

The limitation of LCOE is best demonstrated through real-world data from Europe, where variable renewable penetration is now significant across multiple countries. Whilst wind and solar are often assigned low LCOE figures in Europe, analysis from JP Morgan clearly shows that electricity costs to household consumers tend to rise with renewable penetration[xiii]. This trend is clear even though electricity trade is significant in Europe, effectively allowing countries with large shares of variable renewable capacity to share the costs related to their backup.

Other assumptions

Learning rates

The report assumes technology cost reductions due to 'learning by doing' and makes the unqualified general statement that "technology costs are falling over time".

It is true that major technological improvements over the past several decades have driven down the cost of wind, solar and batteries. However, raw materials now account for the majority of the costs of batteries and solar modules (60-70%) and over 20% of the cost of wind turbines. These material costs are highly likely to rise in the short to medium term; the International Energy Agency's decarbonization scenarios show demand for key minerals used in the manufacture of these technologies, such as lithium, graphite, cobalt and nickel, increasing by 2000-4000% by 2040[xiv].

Modelling costs for wind, solar and batteries based on production volume assumptions and technology learning rates is no longer a credible approach.

Weather data

The report attempts to estimate backup costs for wind and solar based on 9 years of weather data. A recent study modelling solar and wind generation in the UK using 37 years of weather data found variations in supply on a multi-decadal timescale. Its authors concluded that 37 years' worth of data was in fact inadequate and that "…studies of single years or even decades will generally give misleading results."[xv]

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