BRIEFING NOTE

Analysis of Frontier Economics' '*Economic analysis of including nuclear power in the NEM'*

Overview

On 13 December, the Coalition released its estimate of the cost of delivering seven nuclear power stations across the National Electricity Market, based on an 'independent' study that Frontier Economics claims was funded and directed solely by Frontier.

The Frontier report, Economic analysis of including nuclear power in the NEM is the second of two reports released by the firm, aimed at demonstrating that integrating nuclear power stations within the National Electricity Market will be less expensive than pursuing the current Step Change scenario set out within AEMO's Integrated System Plan.

The premise of Frontier's modelling is that it is misleading to *'simply and erroneously [compare] the cost of a renewable generator (wind or solar) plus the costs of back-up generation to the capacity and operating costs of a nuclear power station'*. Frontier argues that instead one should consider 'the total system cost' including generation, storage and transmission.

The headline finding of the first report, Developing a base case to assess the relative costs of nuclear power in the NEM (analysed in an earlier Clean Energy Council briefing note) was that the costs of AEMO's preferred Step Change scenario, which does not include the costs of consumer energy resources, is the sum of the real costs of the electricity supply options of $580b plus the $62b in transmission costs – or a total of $642b. **Importantly, Frontier has revised down that total estimate in its second report, to $594 billion in real dollars, inclusive of transmission costs,** correcting an error in their earlier analysis/report.

The second Frontier report claims that the Coalition's 'Nuclear Alternative' approach, integrating nuclear power alongside renewables and gas, would cost a total of $331 billion (in real, rather than NPV terms) and deliver a $263 billion (44 per cent) saving in total system costs, compared to the delivery of the Step Change scenario, which is supported by the Australian Government.

Some of the major flaws that are evident in the Frontier/Coalition study include:

- An assumption that nuclear power plants can be built and operational starting from 2036. They can't – making the Frontier/Coalition's Nuclear Alternative scenario an impossible and misleading piece of modelling and analysis. See more of our analysis about delivery timeframes on page 6.
- A comparison by Frontier/the Coalition of the Government's and the Opposition's approaches based on two different electricity demand profiles for the economy to 2050, with Frontier/the Coalition selecting the 'Progressive Change' electricity demand profile with lower rates of electrification and uptake of green industries, rather than the higher growth Step Change scenario. Lower demand requires a smaller system build, and a lower capital spend.
- Unrealistically low representation of the total system costs associated with nuclear on the basis that these costs have been spread over a 50-year period, most of which sits beyond the modelling end date of 2051.
- Unrealistically low nuclear construction and operation costs based on estimates that are far lower than recent international experience and independent analysis.

This briefing note examines the report in detailing, outlining **Frontier's findings in Section 1,** the **Clean Energy Council's critique of flaws in the key assumptions in Section 2**, and the Clean Energy Council's **assessment of the impacts to renewable energy investment, deployment and energy consumers in Section 3**.

Section 1: Modelling results overview

Headline findings

Frontier finds that:

1. The total system cost of the AEMO Step Change scenario for the NEM, including utility scale generation, storage and transmission (but excluding consumer energy resources and distribution network augmentation/upgrade costs) costs $594 billion in real dollars. In net present value (NPV), this is calculated to be $225 billion. (See the CEC's briefing note on Frontier's first report for a discussion of the choice of real versus NPV values, and how Frontier's NPV of $225 billion is much higher than AEMO's NPV of $122 billion, based on the annualised capital cost of all utility-scale generation, storage, firming and transmission infrastructure – i.e. excluding costs like VOM/FOM, fuel and emissions costs.)

2. The total system cost of the Coalition's 'Nuclear Alternative' scenario using a Step Change demand scenario is $446 billion in real dollars (or $163 billion in NPV).

3. However, noting that the Coalition's preferred vision of the future includes the slower and lower electrification of vehicles and households, and low domestic production and zero exports of hydrogen, the Frontier report instead highlights the cost of the Nuclear Alternative on the basis of the Progressive Change electricity demand profile, which represents 26 per cent lower electricity demand (operational demand) than AEMO's Step Change scenario (using Frontier's numbers, which exclude DER).
4. In the Nuclear Alternative (Progressive) scenario, Frontier calculates the total system cost to be $331 billion in real dollars (or $124 billion in net present value). This cost is 44 per cent lower than Frontier's estimate of the total system costs of AEMO's Step Change scenario.

From section 1.5.1 Costs, Frontier Economics, Report 2 - Economic analysis of including nuclear power in the NEM

5. By comparing different scenarios, Frontier/the Coalition are able to make the estimated cost differences appear far larger. For example, Figure 1 notes that when AEMO's Step Change is compared to the Nuclear Alternative in a Step Change scenario, the transmission costs of the Nuclear Alternative are 50 per cent higher than the Step Change scenario. Whereas, when comparing AEMO's Step Change with the Progressive Change Nuclear scenario, as Frontier/Coalition have, the transmission cost appears to be almost five times higher.

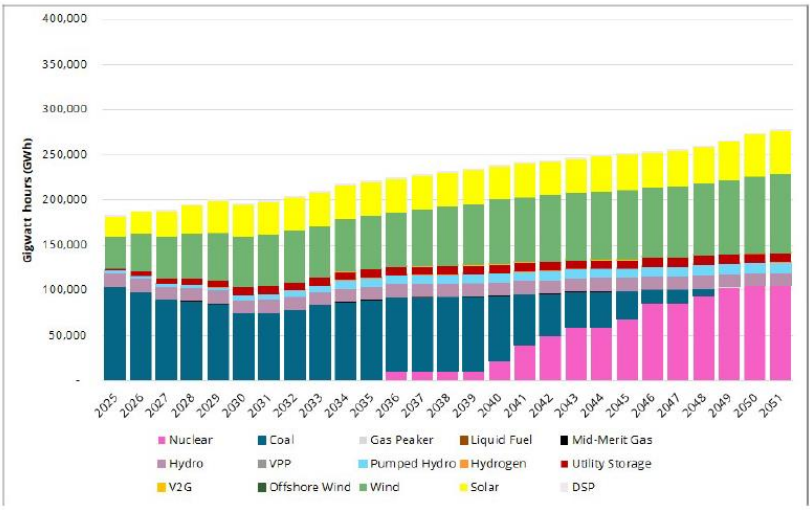
6. Under the Nuclear Alternative (Progressive Change) scenario:

   - The **generation mix by 2051** is **38 per cent nuclear** and **54 per cent renewable**, with generation from utility scale storage and pumped hydro comprising the remaining 8 per cent. There is no gas or coal fired power generation, nor offshore wind in the final electricity generation mix.

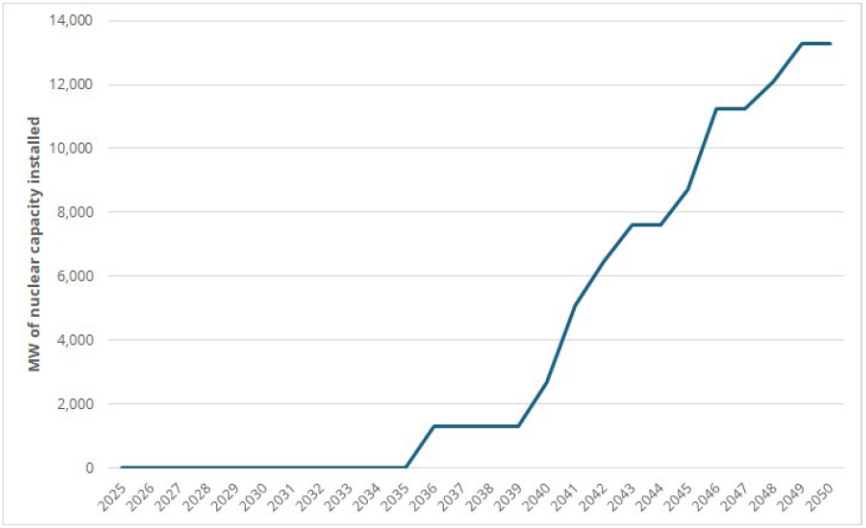
   - **13 GW of nuclear power capacity is assumed to be commissioned across three jurisdictions – New South Wales, Queensland and Victoria – between 2036 and 2049**. All nuclear power plants are large-scale, rather than small modular reactors (which CSIRO has estimated to have a much higher LCOE). On the basis of seven power stations, this works out at one nuclear plant being commissioned every 22 months over a 13-year period. It's worth noting that Frontier explains that the absence of a nuclear power station being established in South Australia simply reflects the fact that there are no coal-fired power stations in South Australia to replace, rather than any finding that a nuclear power station would be uneconomic in South Australia. The Coalition have previously indicated that they would pursue small-modular reactors (a technology which exists in theory rather than in practice) for South Australia and Western Australia.

   - **Onshore wind grows by 2.5 times** from 35,521 GWh in 2025 to 87,468 GWh in 2051; **solar by more than double** from 23,465 GWh in 2025 to 48,351 GWh in 2051, and **pumped hydro by 3.5 times** from 3,117 GWh in 2025 to 11,071 in 2051. See Table 8 on page 34 of the Frontier report to review the full breakdown of the change in generation mix.

Nuclear alternative – Progressive – GWh of electricity production from 2025-2051 (Figure 10, page 33, Frontier Economics, Report 2 - Economic analysis of including nuclear power in the NEM)



Assumed pattern of NEM nuclear generator commissionings (Figure 1, page 7, Frontier Economics, Report 2 - Economic analysis of including nuclear power in the NEM)



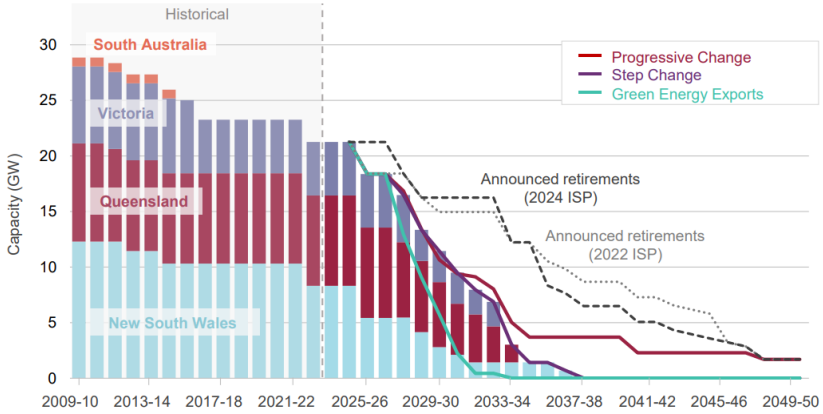
7. *Coal closures*

The Frontier/Coalition 'Nuclear Alternative' scenario envisages a prolonged role for coal-fired generation, with 65 per cent of the current coal fleet having a delayed exit. There is no discussion within the report as to the costs associated with this delayed retirement.

While the ISP's Step Change scenario models a reduction from approximately 22 GW of installed coal-fired capacity in 2024 down to just ~2 GW by 2035, under the Frontier model, coal-fired generation would fall from around 22 GW in 2024 down to around 12-13GW of installed capacity in 2035, and then flatline at this level until the late 2030s, after which coal-fired power stations progressively exit only as nuclear power stations are brought online. The coal-fired power capacity would not fall to 2 GW until 2045, a full decade later than specified in the AEMO Step Change scenario, with the final coal plants closing in 2048. See the comparison of the Frontier closure profile and the Step Change scenario in the two figures overleaf.

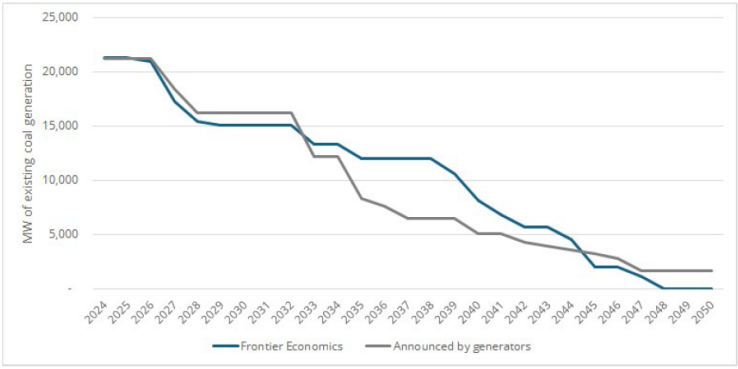
Modelled versus announcement retirement dates under AEMO's Integrated System Plan 2024

Figure 1 **Coal capacity, NEM** (GW, 2009-10 to 2049-50)



Frontier's proposed coal closure timeline

Figure 2: Comparison of closures assumed for modelling and generator announced closures



Source: AEMO and Frontier Economics

Section 2: Critique of Frontier's key assumptions and analysis

Beyond the choice by Frontier/the Coalition to compare the cost of entirely different scenarios, a number of flaws are immediately evident in their Nuclear Alternative modelling:

1. **Unfeasible timeframes for nuclear power plants:** The first of seven nuclear power plants is assumed to come online in 2036 – just eleven years away – which the Clean Energy Council considers to be an impossible timeframe for the delivery of any nuclear power plant in Australia on the basis that:
   - Nuclear power generation is currently illegal and would require parliamentary majorities in both the Federal and State Parliaments for the relevant jurisdictions
   - It will take several years to establish a regulatory framework (e.g. Australia's new offshore wind regulatory framework alone has taken six years to put in place)
   - The plants will take years to both design and have assessed under the new regulatory frameworks (particularly given the heightened community concerns of both host communities and the broader public), and noted from the Clean Energy Council's analysis of the seven nuclear projects delivered or due for delivery after 2015 across OECD countries, the average construction time for projects is approximately 14 years, whereas the average time from scoping to the connection of the plant is 21 years.

Seven nuclear projects delivered or due for delivery after 2015, OECD countries

Project	Country	Reactor type	Total capacity (MW)	Scoping start	Construction start	Cost overrun (AUD)	Connection date	Time to delivery
Olkiluoto 3	Finland	EPR	1600	2000	2005	$13,200,000,000	Apr-23	23
Vogtle Units 3 & 4	USA	AP1000	2234	2006	2013	$31,200,000,000	July 2023 & October 2024	18
Flamanville 3	France	EPR	1650	1999	2007	$16,300,000,000	Late 2024 (expected)	25
Hinkley Point C Units 1 & 2	UK	EPR	3260	2008	2018	$33,900,000,000	2029 & 2031 (expected)	23
Virgil C Summer Units 2 & 3*	USA	AP1000	2234	2005	2013	$23,700,000,000	Cancelled in 2017 due to cost	12
Mochovce Units 3 & 4	Slovakia	VVER-440/V-213	440	2003	Second attempt: 2009 (first in 1986)	$4,260,000,000	Jan 23 & early 25	19
Sizewell C	UK	EPR	3260	2012	2024	$30,380,000,000	Late 2030s (expected)	25
					Total cost overrun of the seven plants	**$152,940,000,000**	***Average delivery time (scoping to connection)***	**21**

Source: Clean Energy Council internal analysis, Dec 2024
Notes: All projects were built on the site of existing nuclear infrastructure; All projects delivered in jurisdictions with high experience in nuclear energy (USA 90+ reactors, UK 15+ reactors, Finland 5 reactors, Slovakia 6 reactors).

- The Clean Energy Council considers that even were there political and public support for nuclear power, on an ambitious timeframe it would take a minimum of two decades before any domestic power plant could be feasibly built, *in addition to* the time required to establish the regulatory framework.

2. **Majority of total system cost of nuclear plants falls beyond the life of the modelling:** Frontier has managed to make the total capex costs of the seven nuclear power plants appear far lower due to its approach of annualising the costs over the expected life of the plant.

   In the case of the nuclear reactors, the presumed life is 50 years (noting that refurbishments are typically required around mid-life, and these refurbishments can take in the order of 3-4 years[1]) and given that the plants begin to come online in the late 2030s and throughout the 2040s, much of the cost therefore falls outside the timeframe of the modelling exercise.

   Meanwhile Frontier's analysis of AEMO's Step Change scenario includes the full capex cost of the renewable energy build, given that it is available now, faster to come online, and has a shorter life.

3. **Underestimation of nuclear construction, and operations & maintenance costs:** The modelling assumes a $10,000/kW for large-scale nuclear reactor construction. While this is higher than CSIRO's latest estimate in the draft GenCost 2024, according to IEEFA analysis, the most recent international experience indicates construction costs of between $15,000-$28,000/kWh, excluding financing costs during the construction period, which can be very significant given the very large capital costs and long construction timeframes.

   In addition to the capex costs, the Frontier report includes a combined fuel and O&M cost of $30/MWh. We note however that CSIRO's latest GenCost report indicates that fuel and O&M costs would be in the order of $40-$60/MWh in 2030, and $36-$56/MWh in 2050.

   Further, it is unclear whether and how Frontier has accounted for nuclear waste management and insurance costs, which could be very high.

4. **Coal extension assumed to be possible within existing operations and maintenance budgets:** The Frontier analysis does not provide any discussion of the potential risks and costs of extending the life of ageing coal-fired power generators beyond their intended or forecast retirement dates. The lead author of the report, Danny Price, has since asserted in a radio interview that coal generators' lives could be extended within the operations and maintenance cost assumptions included within the model. Unfortunately, there is little evidence provided within the report to evaluate the realism of this claim. Given the technical challenges and minimal historical experience involved in extending coal power plants beyond 50 years of life and the fact that banks and other financiers are increasingly applying restrictive lending criteria to coal-fired power plants, we consider that the costings for the nuclear scenarios are also underestimated in this regard.

[1] Jacobson, Mark.Z; *No Miracles Needed*, 2023, page. 163, Cambridge University Press

Section 3: Impacts on renewable energy investment, deployment & consumers

The Nuclear Alternative proposed by Frontier/the Coalition would have significant and direct impacts on the deployment of renewable energy and clean energy investment and economic growth more generally, as outlined below.

1. **Delayed exit of coal fired power generation will dampen the investment case for large-scale renewable energy infrastructure:** The Coalition's proposal to delay the exit of 65 per cent of the existing coal-fired generators across the NEM will damage the investment case for new wind and solar power plants over the next three decades, which rely on both clear market pricing signals and new offtake opportunities to underpin the commercial viability of these capital-intensive builds. The longer the coal-fired generation capacity remains in the system, the more difficult it is to attract clean energy investment.

   Slowed investment and an extended reliance on Australia's fleet of ageing and increasingly unreliable coal fired power generators will also make Australian households, business and industries more vulnerable to unexpected power outages and price spikes.

2. **Heightened probability and frequency of rooftop solar being switched off:** Australia currently benefits from large amounts of low-cost solar power during the day, with solar now installed on four million homes and small businesses across Australia. This frequently results in very low and at times, negative, electricity prices, when there is excess supply compared to demand.

   It is in this context that Frontier/the Coalition nevertheless envisage forcing 13 GW of new and relatively inflexible nuclear capacity into the system, which would operate 24/7, noting that nuclear power plants cannot be turned off. This baseload supply is far larger than the Clean Energy Council regards as feasible or economic in Australia's modernising electricity system. A recent submission by Tesla to the House Select Committee on Nuclear Energy states that the maximum feasible baseload generation in the NEM would be in the order of 2 GW/ 5 per cent of supply.

   We expect that this would place the energy market operator, AEMO, in the position of having to force more flexible and lower cost forms of electricity supply, including solar, wind and pumped hydro, to be turn down or off. Australia's four million solar homes (and growing) would also be vulnerable, and the CEC anticipates that the 'emergency backstop mechanism' would need to be utilised on a far more frequent basis by the market operator. This implies that the payback periods for rooftop solar systems are likely to increase, households will generate less value from their investment, and solar households and businesses will also be subject to purchasing higher cost nuclear power from the grid more frequently.

3. **Uncertainty in relation to transmission build:** Frontier/the Coalition have positioned their Nuclear Alternative as a lower-cost approach on the basis that it will require a lower transmission build. This is not withstanding the fact that GenCost 2024 reported in early December that firmed renewables with integration costs (i.e. Including transmission costs) results in a far lower levelised cost of energy than large-scale nuclear power plants or small modular reactors.

   In practice, while the Coalition's preference is to limit new transmission builds by locating nuclear power plants on the same sites as retiring coal fired power stations, it is not clear whether the Coalition would or could prevent the delivery of the 'actionable' transmission projects currently under development. This requires further analysis. We do note however that the Frontier modelling does not include investment in Renewable Energy Zones.

Clean Energy Council response

The Clean Energy Council issued a media release on Friday 13 December 2024 highlighting the risks of the 'Nuclear Alternative' to renewable energy investment and rooftop solar, and to an orderly and timely clean energy transition.