Australian Resources Development Pty Ltd

Submission regarding GenCost 2022-23 Consultation draft

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Agenda

Executive Summary

Government policies are driving the transition of the Australian electricity industry from reliance on predominantly dispatchable, baseload, coal-fired power to variable renewable energy (**VRE)** sources such as wind and solar, supported by peaking and storage technologies. The major issue concerning all stakeholders (including politicians, electricity industry participants, large and domestic consumers) is the impact of this transition on the cost and reliability of Australia's electricity supply.

Highly pertinent to this issue are the findings of the various CSIRO GenCost reports including the "GenCost 2022-23 Consultation draft" (**Draft GenCost23**) released in December 2022. Draft GenCost23's major conclusion is: "*The analysis confirms that when integration costs are included variable renewables remain the lowest cost new-build technology.*" (Page 56).

Based on this conclusion, policy makers could easily conclude that the transition to low-carbon energy will lower the cost to consumers of a reliable electricity supply.

In this vein, the results of various GenCost reports have been used by politicians, lobbyist and Government agencies to justify both their lack of support for nuclear power generation and their support for the rapid transition to VRE by FY2030. Notable proponents of the GenCost results are the Federal Energy and Climate Change Minister, Mr Bowen, and his department.

The review of Draft GenCost23 presented in this Submission has identified five major issues which cast serious doubts on its conclusion that integrated wind and solar technologies are the cheapest new electricity generation technologies.

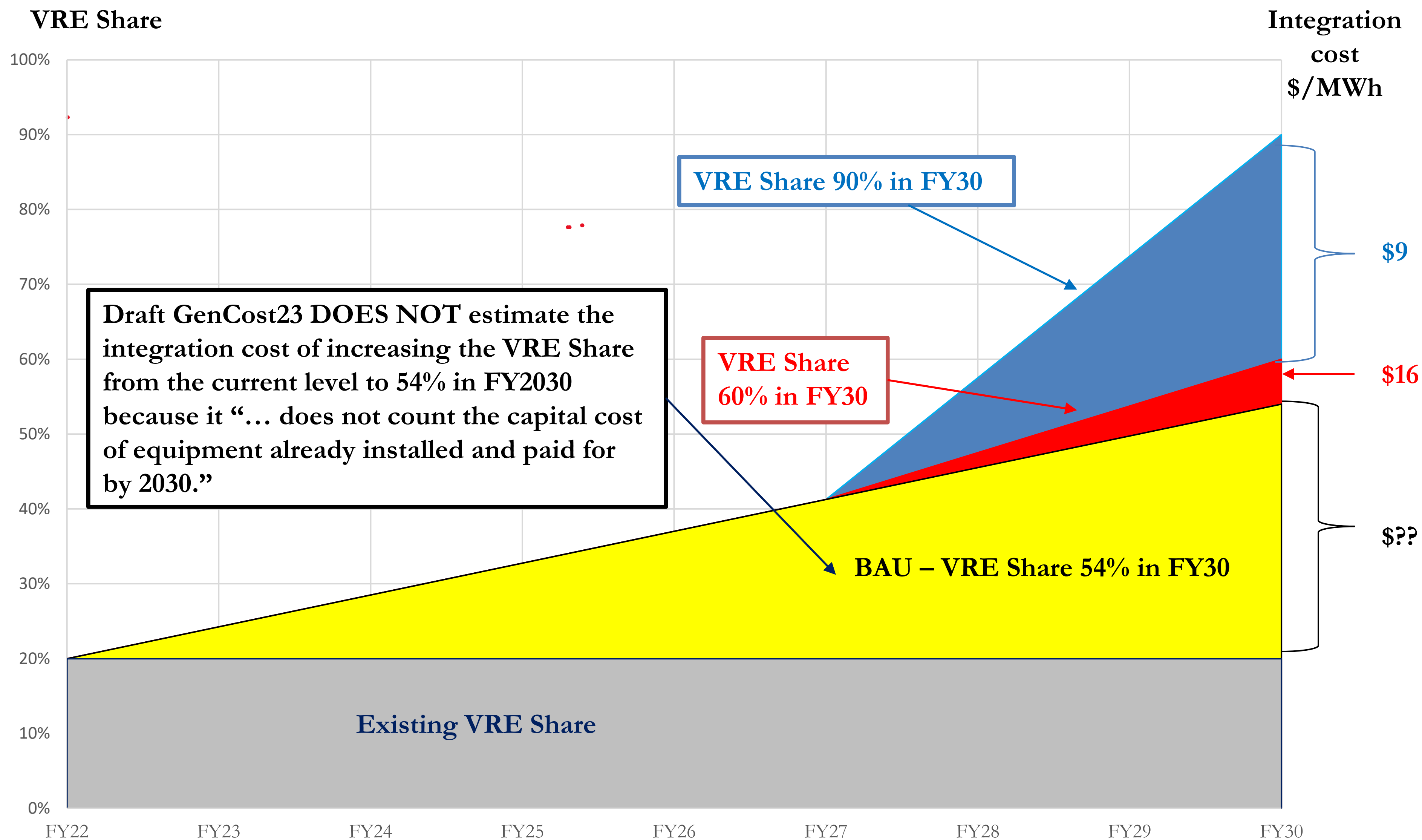
GenCost integration results of little relevance and poorly explained

The GenCost methodology only applies to the cost of integrating additional VRE capacity in FY2030 ABOVE the 54% VRE generation share (**VRE Share**[1]) projected in the business as usual (**BAU**) case in FY2030. That is, the methodology DOES NOT measure the cost of integrating additional VRE capacity above the current level of approximately 20% in FY2022 to approach 54% in FY2030. The methodology is depicted in the following Slide.

Thus, the GenCost results are of little relevance to the major issue TODAY - what is the integration cost to maintain a reliable system while increasing the VRE Share from the current level to 54% by FY2030?

1: Excluding rooftop solar and associated resources.

Diagrammatic depiction of the GenCost integration methodology



Integration is often interpreted as firming

Further, the GenCost reference to "integration" is often interpreted as "firming", a well understood and widely used term in the Australian electricity industry. Based on this interpretation, Minister Bowen and many others conclude that firmed renewables are the lowest cost, new build generation technology.

The final GenCost23 report could reduce the confusion by fully explaining its results by extending its conclusion as follows:

The analysis confirms that, when integration costs are included, variable renewables remain the lowest cost new-build technology AS THE PENETRATION OF VRE GENERATION RISES ABOVE 54% IN 2030. IN THIS CONTEXT, INTEGRATION DOES NOT EQUATE TO FIRMING THE ADDITIONAL RENEWABLE CAPACITY REQUIRED TO INCREASE THE PENETRATION OF VRE GENERATION FROM THE CURRENT LEVEL TO 54% IN 2030.

The confusion could be <u>eliminated</u> in the final GenCost23 report if the integration methodology was extended to include the total cost of maintaining a reliable system as the VRE Share increases from the current level to 54% in FY2030. Under this approach, integration would effectively equate to firming, apart from the capital cost attributable to plant already installed by FY2022. If these additional costs are included, the integration cost is approximately $60/MWh to achieve a 54% VRE Share by FY2030.

This compares with the GenCost23 integration cost of $16/MWh to move from 54% to 60% VRE Share in FY2030 and $25/MWh to move from 54% to 90% VRE Share in FY2030.

Outdated and significantly overstated capital cost estimates for nuclear small modular reactors (SMRs)

Capacity factor assumptions render the proposition that integrated VRE is the lowest cost, new generation technology unfalsifiable

The GenCost methodology uses assumed capacity factors (**CFs**) (annual generation as a proportion of maximum generation) for the various generation technologies to calculate LCOEs.

Under the GenCost methodology, the assumed CFs for fossil-fuel and nuclear SMR baseload technologies are based on the CFs achieved recently by coal plants in the National Electricity Market (**NEM**) that are significantly lower than the technical capabilities of new-build plant. This has the effect of significantly increasing the estimated LCOEs above those achievable when operating those plants at their technical capabilities.

The main reason for the recent CFs being lower than the plants' technical capabilities is the constrained dispatch of those coal plants due to the preference in dispatch given to VRE supported by significant subsidies.

Thus, according to CSIRO's use of recent market history, as subsidised wind and solar generation increases, the CFs of new, baseload technologies reduce which makes them relatively more expensive, thus justifying the even greater use of wind and solar generation, putting aside the cost of the additional support for this capacity. For example, Draft GenCost23 estimates the LCOE of a black coal unit at $84/MWh at an 80% CF. If the CF is forced down to 50%, the LCOE increases to $130/MWh.

This methodology means the proposition that integrated VRE is the lowest cost, new generation technology is self-fulfilling and impossible to disprove – effectively unfalsifiable - and that the consequent GenCost results are of little value to policy makers and stakeholders. On this basis, one could understand CSIRO's comment that there is "… *very little prospect that any plant will be able to operate at high capacity factors due to the existing and likely increasing share of low cost variable renewable generation.*"

This is a flawed method of developing the CF assumptions for baseload plant. The GenCost reports have a critical role to inform stakeholders of the cost trade-offs of replacing fossil-fueled technologies or failing to remove the ban on nuclear power. This is not to say that the transition to a low-carbon energy sector is not important and worthwhile. Rather, this acknowledges that, if Governments and regulators wish to constrain the development of new plants of certain technologies, the cost consequences need to be well understood to compare them with the benefits.

In contrast, the CFs of the VRE technologies are not constrained by technical capability but, rather, by the relevant wind and solar resources available at each time period. However, GenCost assumes CFs for VRE technologies that significantly exceed CFs currently observed in the market.

Modelling issues

The Submission raises several issues relating to the modelling of weather variability and the capability of the GenCost model.

Revised LCOE estimates

Based on the analysis in this Submission, the next Slide contains a Table that sets out the estimated LCOEs for a range of generation technologies in FY2030 for three Cases:

1. The Draft GenCost23 results for the low assumption which only cover the integration costs of moving from 54% VRE Share to 60% and 90% VER Share in FY2030.
2. The Draft GenCost23 results amended to include the estimated integration cost of $60/MWh to move from the approximate 20% VRE Share in FY2022 to 54% VRE Share in FY2030.
3. The amended Draft GenCost23 results from Case 2 further amended as follows:
   - updated SMR cost estimates; and
   - the assumptions of CFs, MLFs and connection costs in the 2022 Integrated System Plan published by the Australian Electricity Market Operator.

The Case 2 results indicate that, in moving from the FY2022 VRE Share to 54% VRE Share in FY2030, the estimated LCOEs of VRE technologies are significantly higher than estimated LCOEs of black coal and gas CCGT.

The Case 3 results indicate that, when amendments are also made for a range of cost and technical assumptions, the estimated LCOEs of VRE technologies are significantly higher than the estimated LCOEs of all other technologies except the small gas turbine technology at a 54% VRE Share.

Again, this is not to say that the transition to a low-carbon energy sector is not important and worthwhile. However, this conclusion highlights the importance of Australian policy makers and stakeholders being better and more reliably informed of the likely future costs of making the transition to a low-carbon generation sector.

For that purpose, an urgent, in-depth review of the Draft GenCost23 findings and their implications is recommended.

Estimated LCOEs in FY2030

The estimated LCOEs in FY2030 for the three Cases are set out in the following Table:

Technology	**Case 1 – Draft GenCost23 Results Low assumption**	**Case 2 – Case 1 plus integration cost to 54% VRE Share in FY2030**	**Case 3 – Case 2 plus amended assumptions**
Black coal	$84	$84	$78
Gas CCGT	$81	$81	$79
Gas turbine small	$163	$163	$108
Gas turbine large	$139	$139	$104
Nuclear (SMR)	$130	$130	$78
Standalone			
Solar PV	$31	$31	$47
Wind onshore	$42	$42	$63
Integrated			
Solar PV - 54% VRE Share	NA	$91	$107
Wind onshore - 54% VRE Share	NA	$102	$123
Solar PV - 60% VRE Share	$47	$107	$123
Wind onshore - 60% VRE Share	$58	$118	$139
Solar PV - 90% VRE Share	$56	$116	$132
Wind onshore - 90% VRE Share	$67	$127	$148

Introduction

This Submission sets out a review of the "GenCost 2022-23 Consultation draft" (**Draft GenCost23**) that will be submitted to the "2023 Inputs Assumptions and Scenarios Consultation" governed by the Australian Energy Regulator's (**AER**) Forecasting Best Practice Guidelines.

CSIRO and the Australian Energy Market Operator (**AEMO**) undertake a now annual process of calculating and publishing estimated costs of building a range of new electricity generation and storage technologies. The process is known as the GenCost project. Its most recent iteration in December 2023 is Draft GenCost23.

This submission makes reference to the following documents:

- Energy Policy Institute of Australia paper 3/2022 "Future Australian Electricity Generation Costs - A Review of CSIRO's GenCost 2021-22 Report" published in September 2022 (**EPIA Paper**).
- CSIRO paper "Response to Energy Policy Institute of Australia paper" published in November 2022 (**CSIRO Response**).

As background, the next Slide presents a summary of the Draft GenCost23 results.

Draft GenCost23 Results

The GenCost methodology uses levelised costs of electricity (**LCOEs**) to summarise the relative competitiveness of new-build[1] generation technologies, including the cost of integrating variable renewable energy (**VRE)** sources such as wind and solar (excluding rooftop solar and associated resources).

The Draft GenCost23 LCOE estimates published in Appendix Table B.9 (page 75) for the low assumptions in FY2030 are reproduced in the following Table except that the integration costs of $16/MWh (60% VRE share of total generation (**VRE Share**)) and $25/MWh (90% VRE Share) (page 56) that Draft GenCost23 applies to the standalone LCOEs of combined wind and large-scale solar PV (**Solar PV**) are applied individually to the standalone wind and Solar PV LCOEs.

Technology	**FY2030 - Low**
Black coal	$84
Gas CCGT	$81
Gas turbine small	$163
Gas turbine large	$139
Nuclear (SMR)	$84
Standalone	
Solar PV	$31
Wind onshore	$42
Integrated	
Solar PV - 60% VRE Share	$47
Wind onshore - 60% VRE Share	$58
Solar PV - 90% VRE Share	$56
Wind onshore - 90% VRE Share	$67

1: Draft GenCost23, page 56 and *"The latest report* (Draft GenCost23) *shows renewables are holding steady at the lowest cost source of new-build electricity"* CSIRO chief executive Larry Marshall, Australian Financial Review, 11 July 2022.

Widespread reliance on GenCost findings

Government policies are driving the transition of the Australian electricity industry from reliance on predominantly dispatchable, base-load coal-fired power to VRE sources such as wind and Solar PV, supported by peaking and storage technologies.

The major issue concerning all stakeholders (including politicians, electricity industry participants, large and domestic consumers) is the impact of this transition on the cost and reliability of Australia's electricity supply.

Highly pertinent to this issue are the findings of the various CSIRO GenCost reports including Draft GenCost23. Indeed, as CSIRO states in the current draft: *"Current and projected electricity generation and storage technology costs are a necessary and highly impactful input into electricity market modelling studies"*. (Page 11).

Such market modelling studies are required by Governments and regulators to assess alternative policies and regulations. The findings also influence public debate on a decarbonised energy economy. In this context, Draft GenCost23 has a critical role to inform policy makers and the public of the cost trade-offs of replacing fossil-fueled technologies while maintaining system reliability.

Draft GenCost23's major conclusion is: "*The analysis confirms that when integration costs are included variable renewables remain the lowest cost new-build technology.*" (Page 56).

Based on this conclusion, policy makers could easily conclude that the transition to low-carbon energy will lower the cost to consumers of a reliable electricity supply.

In this vein, the results of various GenCost reports have been used by politicians, lobbyist and Government agencies to justify both their lack of support for nuclear power generation and their support for the rapid transition to renewable energy by FY2030. For example:

"Mr Bowen said the latest CSIRO GenCost report (Draft GenCost23) *showed nuclear energy was by far the most expensive form of energy in Australia. … The same GenCost report shows firmed renewables, with transmission and storage, are the cheapest form of energy, and getting cheaper every day."* Federal Energy and Climate Change Minister Chris Bowen, Australian Financial Review, 24 January 2023.

Widespread reliance on GenCost findings (cont.)

- *"Prime Minister Anthony Albanese has urged Australia's energy sector to seize a once in a generation opportunity to help make the country a renewable superpower, after promising to legislate emissions reduction targets and pour billions into decarbonising the electricity grid. It follows the market operator and the national science agency confirming renewables remain the cheapest new-build electricity generation option."* InnovationAus.com, 12 July 2022.
- *"In their GenCost 2021-22 report, the CSIRO and AEMO estimate in 2030 the deployment of nuclear power from small modular reactors (SMRs) in Australia could cost between \$136 and \$326 per megawatt hour (MWh)……. the estimated costs in the GenCost 2021-22 report for integrated renewables are between \$53 and \$82MWh in 2030, depending on the level of renewables penetration and including the costs of additional investment in transmission and storage to manage the variable output of renewable energy generators."* The Department of Climate Change, Energy, the Environment and Water (**DECCW**) submission to the Environment and Communications Legislation Committee's inquiry into the Environment and Other Legislation Amendment (Removing Nuclear Energy Prohibitions) Bill 2022 (**Removing Nuclear Prohibition Committee**), 12 January 2023.
- "*Firmed wind and solar still much cheaper than fossil fuels, even with inflation, says CSIRO*", Renew Economy, 16 December 2022.
- The Clean Energy Regulator, a Government body responsible for accelerating carbon abatement for Australia through the administration of several major schemes makes the following statement on its website in discussing large-scale generation certificates:

  "CSIRO's 2021-22 GenCost report confirmed solar and wind are still the cheapest source of new-build electricity generation, even when accounting for component price increases and the additional integration costs such as storage and transmission."
- *"The Gencost report found that a small* (nuclear) *reactor typically costs as much as \$16,000 per kilowatt-hour, 50 to 100 per cent more than large-scale nuclear."*, Australian Financial Review, 11 July 2022.

Such widespread use of the findings of the GenCost reports to justify the major policy changes driving the transition of the Australian energy market puts a significant responsibility on CSIRO to ensure that the findings of Draft GenCos23 are accurate, clearly explained and relevant to the energy transition debate in Australia.

GenCost integration results of little relevance and poorly explained

Under the GenCost VRE integration methodology, an additional process is undertaken to calculate the integration cost to "support" VRE technologies, which is added to the standalone VRE LCOEs. The term "integration" is not defined in the Draft GenCost23 "Shortened form" (Glossary). On page 56 there is a reference to the *"(i)ntegration costs to support renewables"* but the term "support" is not defined.

In the absence of a clear definition, "integration" costs are assumed in this Submission to be the additional costs required to enable an accurate comparison to be made between the estimated integrated VRE LCOEs and those of baseload technologies.

Under the GenCost methodology, the integration costs in FY2030 are calculated against a business as usual (**BAU**) case. In Draft GenCost23, the VRE Share[1] in FY2030 is around 54% in the National Electricity Market **(NEM**). (Page 53).

The integration costs are calculated relative to the BAU case, taking account of any additional costs (capital or operating) associated with new or existing plant for imposed VRE Shares of 60%, 70%, 80% and 90% to project a reliable system. The methodology is depicted in the following Slide.

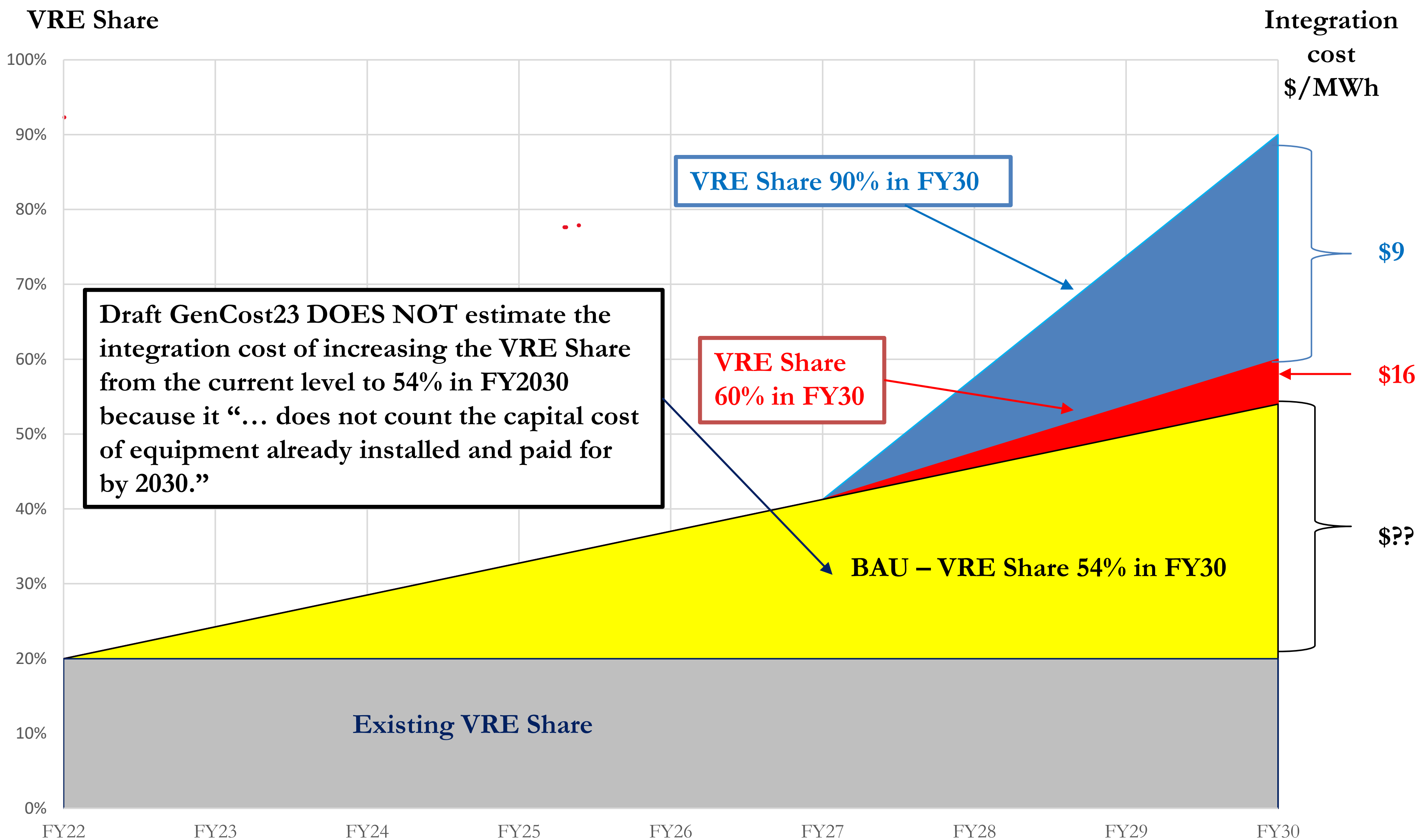
This diagrammatic depiction demonstrates that the GenCost integration methodology only measures the cost of integrating the additional VRE capacity in FY2030 above a 54% VRE Share. That is, the methodology DOES NOT measure the cost of integrating the additional VRE capacity required to increase the VRE Share from its current level of approximately 20% in FY2022 to 54% in FY2030. This very narrow definition of the incremental VRE integration cost above a future level is of little relevance to the major issue TODAY - what is the integration cost to reach a 54% VRE Share in FY2030 from current levels?

The CSIRO *"… modelling does not count the capital cost of equipment already installed and paid for by 2030."* (CSIRO Response, page 12). This reference to *"… paid for by 2030 …"* is illogical:

- The installed units supporting VRE capacity in the 2030 BAU Case will not have reached their assumed economic lives by FY2030, so will not have been *"paid for"* in a financial sense. The phrase implies that CSIRO believes that sunk costs do not need to receive a rate of return.
- In any event, the effective cost of the electricity supplied by these units will be the spot prices during the periods when they are dispatched under the dispatch protocols. These prices will be largely unrelated to the capital cost of the units.

1: Excluding rooftop solar and associated resources.

Diagrammatic depiction of the GenCost integration methodology



GenCost integration is not firming

As evidenced by Minister Bowen, "integration" is often interpreted as "firming", a well understood and widely used concept in the Australian electricity sector relating to achieving a reliable supply of electricity from VRE technologies, backed up by storage and peaking plants.

The EPIA Paper defined firming capacity as the generation and storage capacity required to convert the intermittent electricity from VRE technologies to baseload, dispatchable electricity. (Page 17). This definition is consistent with the following examples:

- Firming is *"(m)aintaining the output from a variable, intermittent power source, such as wind or solar, for a committed period of time*". Firming renewables. A commercial perspective, Matt Bruers, Commercial Advisory Leader, EnergyAustralia, Wind Energy Forum 2019, Melbourne, Slide 3.
- *"… the output of solar and wind generation is as changeable as the weather itself. Complementary engineering solutions in the form of firming technologies, such as battery storage or pumped hydro, are needed to smooth out the ups and downs of variable renewable generation."* Engineering Roadmap to 100% Renewables December 2022, AEMO, Introduction from the CEO, page 5.
- *"Recent and projected market trends indicate that retiring thermal capacity will be almost entirely replaced by variable renewable energy sources – a mix of onshore wind, onshore solar (utility-scale and rooftop PV), and some offshore-wind – with firming provided by a mix of shorter-duration and longer-duration technologies including batteries, hydro plants, as well as new fast-start gas plants such as reciprocating engines and aeroderivative turbines."* Inquiry into the National Electricity Market, November 2022 Report, ACCC, page 24.
- *"By providing firmed energy the Hunter Power Project will facilitate an estimated 1.5 to 2GW of renewables."* Snowyhydro website.

Thus, as currently defined, INTEGRATION is not FIRMING as it fails to take account of the cost of reaching the BAU VRE Share of 54%.

The CSIRO Response agrees with this conclusion as it does not use the term "firming" because it is *"… ill-defined within the electricity industry."* (Page 6).

GenCost integration is not firming (cont.)

One way the final GenCost23 report could <u>reduce</u> the confusion is by clearly explaining the results as follows:

The analysis confirms that, when integration costs are included, variable renewables remain the lowest cost new-build technology AS THE PENETRATION OF VRE GENERATION RISES ABOVE 54% IN 2030. IN THIS CONTEXT, INTEGRATION DOES NOT EQUATE TO FIRMING THE ADDITIONAL RENEWABLE CAPACITY REQUIRED TO INCREASE THE PENETRATION OF VRE GENERATION FROM THE CURRENT LEVEL TO 54% IN 2030.

Further, CSIRO should urgently brief the Minister for Energy and Climate Change, his department and the Government in general to explain clearly the distinction between integration and firming. It should also correct instances where the terms are confused in major broadcasts, presentations and publications.

The confusion could be <u>eliminated</u> in the final GenCost23 report if the integration methodology was extended to include the total cost of maintaining a reliable system as the VRE Share increases from the current level to 54% in FY2030. Under this approach, integration would effectively equate to firming, apart from the capital cost attributable to plant already installed by FY2022.

Cost of integration to achieve 54% VRE Share by FY2030

In order to address the pressing issue today, it is necessary to estimate the cost of integrating the additional VRE capacity to achieve 54% VRE Share by FY2030 under the GenCost Methodology:

- As noted, under this approach, integration would effectively equate to firming.

This requires an estimate of the additional costs (capital or operating) associated with new plant from a base year of FY2022 which would include:

- The capital and operating costs of the numerous generation, transmission and storage projects included in the Draft GenCost23 BAU from FY2022 to FY2030.
- The capital and operating costs of the additional projects necessary before 2030 identified in the AEMO 2022 Integrated System Plan (**ISP22**).

These costs could exceed $60 billion after allowing for further inevitable delays and cost blow outs.

If these costs are included, the integration cost is approximately $60/MWh to achieve a 54% VRE Share by FY2030.

This compares with the GenCost23 integration cost of $16/MWh to move from 54% to 60% VRE Share in FY2030 and $25/MWh to move from 54% to 90% VRE Share in FY2030.

Assumed capital costs of small nuclear modular reactors (SMRs)

Draft GenCost23 lists the cost of the nuclear SMR technology in FY2030 as $7,355/kW (low case) and $15,853/kW (high case).

The low case assumption is based on the greater deployment of SMRs in the Global NZE scenarios. SMR technology costs are not assumed to improve significantly over the period to 2050.

The high case assumption is based on the 2018 GHD nuclear cost review for CSIRO which drew on a 2015 International Energy Agency (**IEA**) report and a 2019 study for the Canadian Nuclear Association. The GHD review simply doubled the cost of a large reactor to $16,000/kW. Minister Bowen often refers to this high case assumption to prove that nuclear power is too expensive. Also, the DECCW submission to the Removing Nuclear Prohibition Committee's inquiry totally relied on GenCost reports to justify the claim that the cost of electricity from SMRs is excessive.

However, the IEA updated its report in 2020 to include updated cost estimates for new-build, nuclear generating technologies in various countries for large-scale units. These indicate that there has been a 21% reduction in costs in five years in Australian dollar terms. Further, recent international results for SMRs indicate a cost of approximately $4,100/kW.

Apart from the rapid reduction in unit cost, a recent IEA nuclear tracking report noted that achieving *"…net zero globally will be harder without nuclear"* and projects nuclear power to double between now and 2050. The momentum to achieve NetZero2050 can reasonably be expected to result in cost reductions from the IEA 2020 estimates.

Based on the analysis set out in Appendix 1, a unit cost of $5,500/kW in FY2030 is used to test the impact on the estimated SMR LCOE.

More generally, developments in the international nuclear power industry are moving rapidly towards the realisation that nuclear power is needed to achieve net-zero while maintaining living standards. For instance, the UK Government recently announced that nuclear energy will be given "green" status to aide in the UK's pursuit of net-zero. This follows the announcement in December 2022 that the UK and US Governments would *"… step up efforts to promote nuclear power as a "safe and secure" domestic energy source amid a new partnership aimed at accelerating the transition to low-emission economies and to reach their net-zero commitments."* Sydney Morning Herald, 7 December, 2022.

Thus, CSIRO should take notice of these developments regarding nuclear power's role in the achievement of net-zero globally while maintaining living standards and develop current, realistic cost assumptions for SMRs.

Assumed VRE capacity factors significantly exceed current observations

The GenCost methodology uses assumed capacity factors (**CFs**) (annual generation as a proportion of maximum generation) for the various generation technologies to calculate LCOEs.

Draft GenCost23 assumes a CF range for wind of 35% - 46% in FY2030 and for Solar PV of 19% - 32%. Given preferential dispatch, the CFs of the VRE technologies are not constrained by technical capability but, rather, by the relevant wind and solar resources available at each time period.

These ranges are significantly higher than the CFs used in the ISP22. CSIRO acknowledges this but states that it is only interested in the *"… plausible maximum and minimum costs"* and *"makes no promise that the midpoint of this range is aligned to those achieved in the electricity market or with AEMO's ISP renewable energy zone data averages."* CSIRO Response, page 8.

That is, the assumed GenCost CFs are not related to market reality as even the minimum assumptions exceed the CFs currently being achieved. Thus, it is difficult to accept that such assumptions are *"plausible"*.

As a reality check, the FY2022 CFs for the NEM were 29% for wind and 19% for Solar PV (which include the impact of marginal loss factors (**MLFs**) which are ignored in the GenCost methodology to calculate LCOEs).

On the assumption that the better VRE sites have been taken first, it is reasonable to assume that CFs for new-build VRE technologies will be lower than the CFs currently being achieved.

Assumed baseload capacity factors significantly less than technical capability

Draft GenCost23 assumes a 60% - 80% CF range for fossil-fuel and nuclear SMR baseload technologies based on CFs achieved recently by coal plants in the NEM that are significantly lower than the technical capabilities of new-build plant. This has the effect of significantly increasing the estimated LCOEs above those achievable when operating those plants at their technical capabilities.

The CSIRO Response justified the use of recent market history as follows: *"The capacity factor GenCost assigns to baseload plant are generous considering the realised capacity factors are low and getting lower. There would be no benefit to the reader in assigning a "technically achievable capacity factor". There is very little prospect that any plant will be able to operate at high capacity factors due to the existing and likely increasing share of low cost variable renewable generation."* (Pages 3-4).

However, the main reason for the recent CFs being lower than the plants' technical capabilities is the constrained dispatch of those coal plants due to the preference in dispatch given to VRE supported by significant subsidies.

Thus, according to CSIRO's use of recent market history, as subsidised wind and Solar PV generation increases, the CFs of baseload technologies reduce which makes them relatively more expensive, thus justifying the even greater use of wind and Solar PV generation, putting aside the cost of the additional support for this capacity.

For example, Draft GenCost23 estimates the LCOE of a black coal unit at $84/MWh at an 80% CF. If the CF is forced down to 50%, the LCOE increases to $120/MWh.

This methodology means the proposition that integrated VRE is the lowest cost, new generation technology is self-fulfilling and impossible to disprove – effectively unfalsifiable - and that the consequent GenCost results are of little value to policy makers and stakeholders.

On this basis, one could understand CSIRO's comment above. In passing, CSIRO's use of pejorative language to justify its CF assumptions is unfortunate but, perhaps, symptomatic of an organisation that cannot, or will not, take a dispassionate view on non-VRE technologies.

This is a flawed method of developing the CF assumptions for baseload plant.

Assumed baseload capacity factors significantly less than technical capability (cont)

The GenCost reports have a critical role to inform stakeholders of the cost trade-offs of replacing fossil-fueled technologies or failing to remove the ban on nuclear power. This is not to say that the transition to a low-carbon energy sector is not important and worthwhile. Rather, this acknowledges that, if Governments and regulators wish to constrain the development of new plants of certain technologies, the cost consequences need to be well understood to compare them with the benefits.

As noted in the EPIA Paper, the Australian Competition and Consumer Commission addressed the potential Government role to support projects that face uncertainty regarding the future environment for businesses such as fossil-fuel or SMR baseload generation technologies in *"appropriate circumstances."* (Page 16). As the grid has deteriorated, the prospect of capacity payments has arisen. It is not a large step for the Government offering power purchase agreements to prevent major outages (i.e., *"appropriate circumstances"*).

Failure to take account of connection costs and marginal loss factors

As noted, Draft GenCost23 fails to take account of the assumed connection costs and MLFs for the various technologies.

Baseload technologies can be located near large load centres and associated fuel supply and transmission infrastructure which leads to relatively low connection costs and MLFs.

In contrast, VRE technologies are generally located in areas remote to the grid and load centres which leads to relatively high connection costs and MLFs.

The inclusion of connection costs and MLFs increases the unit costs and lowers the effective CFs of VRE generation technologies relative to baseload technologies.

Estimated LCOEs in FY2030

Based on the analysis in this Submission, the next Slide contains a Table that sets out the estimates LCOEs for a range of generation technologies in FY2030 for three Cases:

1. The Draft GenCost23 results which only cover the integration costs of moving from 54% VRE Share to 60% and 90% VER Share in FY2030.
2. The Draft GenCost23 results amended to include the estimated integration cost of $60/MWh to move from the approximate 20% VRE Share in FY2022 to 54% VRE Share in FY2030.
3. The amended Draft GenCost23 results from Case 2, further amended as follows:
   - updated SMR cost estimates; and
   - the 22ISP assumptions of CFs, MLFs and connection costs.

The Case 2 results indicate that, in moving from the FY2022 VRE Share to 54% VRE Share in FY2030, the estimated LCOEs of VRE technologies are significantly higher than the estimated LCOEs of black coal and gas CCGT.

The Case 3 results indicate that, when amendments are also made for a range of cost and technical assumptions, the estimated LCOEs of VRE technologies are significantly higher than the estimated LCOEs of all other technologies except the small gas turbine technology at a 54% VRE Share.

Estimated LCOEs in FY2030

The estimated LCOEs in FY2030 for the three Cases are set out in the following Table:

Technology	Case 1 – Draft GenCost23 Results Low assumption	Case 2 – Case 1 plus integration cost to 54% VRE Share in FY2030	Case 3 – Case 2 plus amended assumptions
Black coal	$84	$84	$78
Gas CCGT	$81	$81	$79
Gas turbine small	$163	$163	$108
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Nuclear (SMR)	$130	$130	$78
Standalone			
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Wind onshore	$42	$42	$63
Integrated			
Solar PV - 54% VRE Share	NA	$91	$107
Wind onshore - 54% VRE Share	NA	$102	$123
Solar PV - 60% VRE Share	$47	$107	$123
Wind onshore - 60% VRE Share	$58	$118	$139
Solar PV - 90% VRE Share	$56	$116	$132
Wind onshore - 90% VRE Share	$67	$127	$148

Modelling issues

The major determinant of the generation from wind and Solar PV technologies are wind speeds and irradiance levels (**VRE Resources**) in each time period. A major issue is that the NEM regions are regularly subject to extensive periods when VRE Resources are low (**Weather Droughts**).

Draft GenCost23 accounts for Weather Droughts by using the maximum integration costs modelled over nine weather years and states that the *"… maximum cost represents a system that has been planned to be reliable across the worst outcomes from weather variation."* (Page 55).

The analysis of AEMO data reported by the Independent Engineers and Scientists in their "Response to Draft AEMO Integrated System Plan, 10 February 2022" shows multiple events of wind CFs below 10%, lasting at least 18 hours. In other periods, CFs dropped to virtually zero for days (see Appendix 2). Solar PV CFs are highly variable based on time of day and season as well as prevailing weather conditions.

Further, AER's Wholesale Markets Quarterly for Q2, 2022, highlighted the impact of Weather Droughts as follows:

- *"… on average, there was less solar electricity generated (in Queensland) per MW of capacity in 2022 than 2021. This pattern is consistent with impacts in other regions. This not only impacts large scale solar generation but also rooftop solar generation (effectively increasing demand). This resulted in other generators needing to operate at higher levels than anticipated to meet demand."* (Page 16).
- *"While wind output levels vary markedly from week to week, average output from wind in SA was down for two-thirds of the weeks of the quarter. Wind levels were particularly low in the week leading up to market suspension. In weeks where wind is low, other generators need to operate at higher levels to meet demand."* (Page 17).

This issue was raised in the EPIA Paper and the CSIRO Response included the following statement: *"STABLE uses the variable renewable production profiles published by AEMO."* (Page 15). Presumably, this data relates to the nine weather years and should be published in the Draft GenCost23 support documents.

The CSIRO Response also included the statement: *"Given Australia's large size, weather events are mostly non-synchronous across the length of the NEM."* (Page 14). To the extent that this assertion relates to the nine weather years, CSIRO needs to provide the evidence as the assertion contradicts the results of other studies (e.g., GenInsights21, Deep Dive 27 – Exploring Wind Diversity).

Modelling issues (cont.)

"GenCost 2020-21 Final report" (**GenCost21**) applied the CSIRO STABLE model to estimate the optimised investment profile and operation to achieve reliability and security. STABLE is described as an intermediate horizon model that co-optimises "*… investment and operation for reliability and security (one to several hours time steps for one to five years)*" (page 55).

Based on this description, the EPIA Paper questioned whether the STABLE model optimised system investment over a short-enough period (e.g., half hours) to measure the impact of Weather Droughts effectively.

The CSIRO Response stated: *"STABLE uses an hourly representation of time. … The current compromise to use hourly time intervals remains the right one under current knowledge and for GenCost purposes."* (Page 15).

Draft GenCost23 makes no reference to the "STABLE model" but makes numerous references to the "model'. For example:

"We calculate the integration costs of renewables for 2030, imposing a required variable renewable energy (VRE) share and running the model to determine the optimal investment to support the VRE share." (Page 53).

In view of the conflict between the two reports, CSIRO needs to provide the following information in the final GenCost23 report:

- ❑ Confirmation of whether the STABLE model, as defined in GenCost21, was used to produce the results provided in the final GenCost23.
- ❑ If not, what were the time steps of the model used - "one to several hours time steps for one to five years" used in the STABLE model or hourly time steps over the 49 years to 2050 pursuant to the CSIRO Response?
- ❑ The annual estimated installed capacity, generation and other relevant results in line with AEMO's policy in such files as "2022 Final ISP results workbook - Step Change - Updated Inputs".
- ❑ The report of an independent audit of the model, confirming that it has the capability to undertake the tasks claimed by CSIRO.

Conclusion

In announcing the release of Draft GenCost23, CSIRO's major conclusion was: "*This confirms past years' findings that wind and solar are the cheapest, even when considering additional integration costs arising due to the variable output of renewables, such as energy storage and transmission.*"

This Submission has shown that this conclusion only applies to the cost of integrating additional VRE capacity in FY2030 above 54%. That is, the methodology DOES NOT measure the cost of integrating additional VRE capacity above the current level of approximately 20% in FY2022 to 54% in FY2030.

This result is of little relevance to the major issue TODAY - what is the integration cost to reach a 54% VRE Share[1] in FY2030 from the current VRE Share of approximately 20%?

Moreover, "integration" is often interpreted as "firming", a well understood and widely used term in the Australian electricity industry. The final GenCost23 report could eliminate the confusion by clearly explaining the results as follows:

The analysis confirms that, when integration costs are included, variable renewables remain the lowest cost new-build technology AS THE PENETRATION OF VRE GENERATION RISES ABOVE 54% IN 2030. IN THIS CONTEXT, INTEGRATION DOES NOT EQUATE TO FIRMING THE ADDITIONAL RENEWABLE CAPACITY REQUIRED TO INCREASE THE PENETRATION OF VRE GENERATION FROM THE CURRENT LEVEL TO 54% IN 2030.

Further, CSIRO should urgently brief the Minister for Energy and Climate Change, his department and the Government in general to explain clearly the distinction between integration and firming. It should also correct instances where the terms are confused in major broadcasts, presentations and publications.

The confusion could be <u>eliminated</u> in the final GenCost23 report if the integration methodology was extended to include the total cost of maintaining a reliable system as the VRE Share increases from the current level to 54% in FY2030. Under this approach, integration would effectively equate to firming, apart from the capital cost attributable to plant already installed by FY2022.

1: Excluding rooftop solar and associated resources.

Conclusion (cont.)

This Submission also identified major deficiencies and omissions with the Draft GenCost23 data assumptions including:

- Outdated and significantly overstated capital and operating cost estimates for nuclear SMRs.
- Assumed capacity factors to calculate LCOEs for VRE technologies that significantly exceed capacity factors currently observed in the market.
- Assumed capacity factors to calculate LCOEs for baseload technologies based on current market observations that are significantly lower than the technical capabilities of new-build plant. The use of the market history rather than technical capability means that the proposition that integrated VRE is the lowest cost, new generation technology is unfalsifiable and that the consequent results are of little value to policy makers and stakeholders.
- A failure to take account of connection costs and marginal loss factors in calculating LCOEs which are relatively high for VRE technologies.
- Issues concerning the modelling of weather droughts and the model used to generate the Draft GenCost23 results.

If the Draft GenCost23 LCOE estimates are adjusted for these issues, the integrated VRE technologies are not the cheapest new generation technologies, being more expensive than all other technologies except the small gas turbine technology at a 54% VRE Share.

This is not to say that the transition to a low-carbon energy sector is not important and worthwhile. However, this conclusion highlights the importance of Australian policy makers and stakeholders being better and more reliably informed of the likely future costs of making the transition to a low-carbon generation sector.

For that purpose, an urgent, in-depth review of the Draft GenCost23 findings and their implications is recommended.

Recommendations

Based on the conclusions of this Submission, the following recommendations are made to CSIRO regarding the development of the final GenCost23 report:

- If CSIRO persists in calculating integration costs relative to the BAU case, the following clarifying statement should be included in the final GenCost23 report:

  The analysis confirms that, when integration costs are included, variable renewables remain the lowest cost new-build technology AS THE PENETRATION OF VRE GENERATION RISES ABOVE 54% IN 2030. IN THIS CONTEXT, INTEGRATION DOES NOT EQUATE TO FIRMING THE ADDITIONAL RENEWABLE CAPACITY REQUIRED TO INCREASE THE PENETRATION OF VRE GENERATION FROM THE CURRENT LEVEL TO 54% IN 2030.

  Further, the Minister for Energy and Climate Change, his department and the Government in general should be urgently briefed to explain clearly the distinction between integration and firming. Also, instances where the terms are confused in major broadcasts, presentations and publications should be corrected.

- The confusion could be <u>eliminated</u> in the final GenCost23 report if the integration methodology was extended to include the total cost of maintaining a reliable system as the VRE Share increases from the current level to 54% in FY2030. Under this approach, integration would effectively equate to firming, apart from the capital cost attributable to plant already installed by FY2022.

- Take notice of the major developments with respect to the construction of SMRs and nuclear power's role in the achievement of net-zero globally while maintaining living standards and develop current, realistic cost assumptions for SMRs.

- In calculating LCOEs:
  - Base the assumed capacity factors for VRE technologies on the capacity factors currently observed in the market.
  - Base the assumed capacity factors for baseload technologies on the technical capabilities of new-build plant.
  - Take account of connection costs and marginal loss factors.

Recommendations (cont.)

- Publish the nine weather years' data in the final GenCost23 support documents.
- Provide the following information in regard to the final GenCost23 modelling:
  - Was the STABLE model, as defined in GenCost21, used to produce the results provided in the final GenCost23 report?
  - If not, what were the time steps of the model used - "one to several hours time steps for one to five years" used in the STABLE model or hourly time steps over the 49 years to 2050?
  - The annual estimated capacity, generation and other relevant results in line with AEMO's policy in such files as "2022 Final ISP results workbook - Step Change - Updated Inputs".
  - The report of an independent audit of the model, confirming that it has the capability to undertake the tasks claimed by CSIRO.

Appendix 1: SMR capital cost assumptions

Draft GenCost23 lists the cost of nuclear SMR in FY2030 as $7,355/kW in the low case assumption and $15,853/kW in the high case assumption (Table B.8, page 73).

According to "GenCost 2021-22 Final report" (**GenCost22**), the low assumption is based on the greater deployment of SMRs in the Global NZE scenarios. (Page 40). The current assumption is slightly lower than the GenCost22 assumption in real terms.

The high case assumption is based on the 2018 GHD nuclear cost review for CSIRO which provided a figure of $16,000/kW for an SMR for the GenCost 2018 report. The 2015 International Energy Agency (**IEA**) and Nuclear Energy Association report (**IEA2015**) "Projected Costs of Generating Electricity" includes a statement *"… the specific per-MW costs of SMRs are likely to be higher (typically 50% - 100% higher per kWe for a single SMR plant) than those of large generation III reactors."* (Page 159). This statement was used to justify the increase of the $8,000/kW cost of a large reactor to $16,000/kW. GenCost22 quoted IEA2015 as the justification for the 100% increase for Australia *"… reflecting our limited experience in nuclear generation…"* (Page 14). This was supported by a 2019 study for the Canadian Nuclear Association (**CNA2019**) which GenCost22 listed as the *"most recently available"* (page 17) data source for SMRs.

However, the IEA has updated its report "Projected Costs of Electricity Generation 2020" (**IEA2020**) and included updated cost estimates for new-build, nuclear generating technologies in various countries provided in IEA2015. The most recent IEA nuclear tracking report noted that achieving *"…net zero globally will be harder without nuclear"* and projects nuclear power to double between now and 2050.

Both reports list the average cost for predominantly light water reactors denominated in US dollars. The 2015 estimate has been escalated to 2022 terms by the US consumer price index and both estimates converted to Australian dollars at a 0.70 AUD/USD exchange rate. The results are as follows:

Source	AUD/kW
IEA2015	$7,670
IEA2020	$6,040

Appendix 1: SMR capital cost assumptions (cont.)

The results for large-scale units indicate that there has been a 21% reduction in costs in five years in Australian dollar terms. In this context, the assumption that there is virtually no reduction in nuclear capital costs by 2050 appears unrealistic.

The GenCost22 assumption was developed by increasing the IEA2015 estimate to account for the higher cost of SMRs relative to large scale nuclear units and Australia's limited experience in nuclear generation.

In relation to the scale issue between large generation III reactors and SMRs, NuScale[1] "*… believes that it will need to fabricate 12 to 14 modules to move down the learning curve from first-of-a-kind to "Nth-of-a-kind".*" (NuScale UK Prospectus, page 22). For a nuclear generator with the 77 MWe modules, the Nth-of-a-kind cost from NuScale is US$2,850/kW (Power Magazine, 11 November 2020) which converts to $4,100/kW Australian dollars at a 0.70 AUD/USD exchange rate. This unit cost is significantly lower than the IESA2020 estimate for large-scale plants.

The momentum to achieve NetZero2050 can reasonably be expected to result in cost reductions from the IEA2020 estimate. The IEA cost estimates have fallen by 21% in the five years to FY2020 or 4% per year. A conservative annual reduction of approximately 2% would yield a cost below $5,000/kW in FY2030.

Based on this analysis and the latest NuScale SMR Nth-of-a-kind cost of $4,100 and an allowance to translate the costs to Australian conditions, a unit cost of $5,500/kW in FY2030 is used to test the impact on the estimated SMR LCOE.

Draft GenCost23 assumes fixed O&M of $200/kW/year and variable O&M of $5.30/MWh. Based on recent NuScale cost these are reduced to $100/kW/year and $0/MWh respectively.[2]

All other Draft GenCost23 assumptions regarding SMRs are used except the capacity factor, which is based on the technical capability of this baseload technology as well as a connection cost and a MLF comparable with the siting of a baseload plant capable of operating at high CFs.

1: NuScale Power Corporation, listed on the New York Stock Exchange.

2: GenCost2022-23 Submission by SMR Nuclear Technology Pty Ltd.

Appendix 2: Evidence of Weather Droughts

The data in the following Table is drawn from the following study: "Response to Draft AEMO Integrated System Plan", 10 February 2022, Independent Engineers and Scientists, Table 1, page 11.

Periods of Wind Capacity Factor Below 10%			
Year	Number of Periods	Minimum Period hrs	Maximum Period hrs
2011	6	18	74
2012	19	20	67
2013	9	19	54
2014	14	20	46
2015	16	18	39
2016	6	18	61
2017	18	18	72
2018	6	18	57
2019	4	18	40
2020	4	18	33
Table 1 SE Australia Wind Capacity Factor Data			

Glossary

Abbreviation	Meaning
AER	Australian Energy Regulator
AEMO	Australian Energy Market Operator
BAU	Business as usual
CFs	Capacity factors, the proportion of the year that a plant is generating
CSIRO Response	The CSIRO paper "Response to Energy Policy Institute of Australia paper", November 2022
Draft GenCost23	"GenCost 2022-23 Consultation draft", December 2022
EPIA Paper	Energy Policy Institute of Australia paper 3/2022 "Future Australian Electricity Generation Costs - A Review of CSIRO's GenCost 2021-22 Report", September 2022
GenCost21	GenCost 2020-21- Final report, July 2021
GenCost22	GenCost 2021-22 Final report, July 2022
Draft GenCost23	GenCost 2022-23 Consultation draft, December 2022
ISP22	AEMO 2022 Integrated System Plan
LCOE	Levelised cost of electricity
MLF	Marginal loss factor
NEM	National Electricity Market
Solar PV	Large-scale Solar PV
VRE	Variable renewable energy
VRE Resources	Wind speeds and irradiance levels in each time period
VRE Share	VRE generation share
Weather Drought	An extensive period when VRE Resources are low

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