Storage requirement for 100 percent Renewables on the Eastern Australian Grid

Executive Summary - Notes for policymakers

BESS Batteries are NOT generators

In the present unseemingly, mad, rush in Australia to introduce what looks to be the latest and greatest in renewables and associated technologies, policymakers seem to have forgotten that batteries, whether utility-scale BESS batteries, or otherwise, are batteries. They are NOT and never will be generators. They cannot replace fossil-fuelled generators, even when symbolically placed on the same site as a decommissioned fossil-fuelled power plant.

Like any other battery, once its stored charge has been used, a BESS has to be recharged from a generator. Tellingly, BESS were never required to support a grid powered by fully dispatchable generators. These batteries are required only because generators such as wind and solar generators are by their very nature, non-dispatchable, highly-variable-output, unpredictable, intermittent generators. That is, these batteries are required as a “band-aid” to deal with the very real deficiencies of these so-called “renewable” forms of generation.

As the sole purpose of a BESS is that of acting as a ‘band-aid’ to wind and solar generators, it should be seen as a very necessary item of ancillary equipment, and as such, should NOT be seen as an item which would attract any form of “renewables” subsidy. Furthermore, the very real, very large CO_2 emissions embedded in the.production of any BESS should be counted against any supposed emissions reductions that might be achieved by the “renewable” generator that it is alleged that it is being used to support.

Preamble

As stated in the Conclusions below:
It would seem that Australian government authorities have either not performed and/or have not made publicly available any analysis that provides any indication whatsoever, in a readily understandable way, how many “Big Batteries” will be required in Eastern Australia to meet the proposed 100-percent Renewables’ Storage requirement; how these Big Batteries will be sourced and paid for, what are the energy requirements for their production, what safety procedures have been put in place given the known fire risk from these battery technologies, what waste disposal procedures, if any, are envisaged, and the CO_2 emissions resulting therefrom, and, importantly, where these batteries are to be sited, and, given their relatively short service life, how they are to be recycled and re-used.

It beggars belief that none of this absolutely necessary preliminary, investigative work seems to have been addressed by the relevant Australian Planning Authorities.

Clearly, these Authorities perceive that this Battery Storage requirement is merely a minor matter.

To, the contrary, this analysis finds that the Battery Storage requirement is very much a matter that has grave consequences, both for the Eastern Australian Grid, and for the National Economy - hardly a minor matter.

Summary of Findings

In summary, the findings of this analysis are:

From an analysis based on the AEMO Generator and Operational Demand data for the full period of the calendar years 2023-2024, to even begin to consider a 100-percent Renewables scenario for the Eastern Australian Grid:

1. The present wind and solar energy facilities complement will need to be increased, as a minimum, by a factor of 3.31.
2. The minimum Storage Requirement to provide coverage during the worst extreme, prolonged minima in output of the renewables, must be able to supply the full Demand for a minimum period of 41.1 days. This translates to a Storage Requirement of 20,625,000 MWh, equivalent to some 45,833 Geelong Big Batteries, or some 159,884 Hornsdale Big Batteries.

Clearly, this Battery Storage requirement is unachievable. That it is so has the potential for dire consequences should it continue to be pursued. As a result, in their pursuit of a 100-percent renewables electricity generation target, policymakers need to understand very clearly that should this storage requirement not be fully completed, that is, at the outset of any proposed closure of dispatchable fossil-fuelled generation, a permanent regime of frequent, unpredictable, widespread blackouts is the only possible outcome.

Also, policymakers need to bear, again very clearly in mind, that with the closure of fossil-fuelled generation, it is absolutely essential that the consequent loss of synchronous inertia be replaced by a reliable, proven, available-at-all-times “grid-firming” substitute. If it is envisaged that this is to be somehow managed with battery storage, this merely adds to the onerous battery storage requirement already identified in this analysis.

If these matters are not addressed then the twin effects of the resulting social disruption, and the impact on the Australian economy, of an ongoing regime of widespread electricity blackouts, do not bear thinking about.

Estimated Cost of the necessary battery storage as a proportion of annual GDP

At a cost of some $USD200/kWh, (Menton, F., *pers. comm*). the cost of this storage comes to some $USD4.125 trillion. For comparison, Australia’s total GDP at the end of 2025 is estimated as $USD1.818 trillion[1] So the total battery storage cost is estimated as being some 2.27 times Australia’s GDP for calendar year 2025.
Clearly, any proposed buildout of battery storage on this scale is unattainable.

Land take

According to: https://victorianbigbattery.com.au/faqs/ , the Geelong battery covers an area of the same size as the Geelong Kardinia Park GMHBA Stadium field. This is an area of some 2 hectares.

There does seem to be some disagreement as to the size of the area occupied. According to the link https://moorabool.com.au/faqs/, the battery occupies some 4 hectares. I have used the 2 hectare figure in the following calculations.

[1]Source: https://www.worldeconomics.com/GDP/Australia.aspx

Some 46,000 Geelong Big Batteries would occupy an area, a minimum area, of some 92,000 hectares. This does not include the area required for the corridors for the necessary connecting transmission lines. It is clear that government policy is to acquire rural lands for this purpose, rural lands which are predominantly farmland, that is, land used for food production. This makes it a very significant land grab. This land take is in addition to the considerable amount required for the additional wind and solar "farms", each of which itself constitutes a very significant land grab.

Taking over farmland to build facilities to produce intermittent energy is a violation of Article 2, Section 1(b) of the Paris Agreement (2015).

Article 2 1(b) of the 2015 Paris Agreement states:

"This Agreement… aims to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty, including by:
"(b) Increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development, **in a manner that does not threaten food production";** See: https://unfccc.int/files/essential_background/convention/application/pdf/english_paris_agreement.pdf .

Policymakers need to understand, and to understand very clearly, that these storage batteries are merely a band-aid; they would not be necessary except for very serious shortcomings in the forms of generation – the intermittent renewables - that these batteries are required to support.

A battery does NOT extract energy from the wind or the sunshine. These batteries are required simply because both solar and wind generation are highly intermittent forms of generation and these forms of intermittent generation have a major failing: neither is dispatchable. These forms of generation are also incapable, unlike conventional generation, of providing, automatically, at all times the very necessary synchronous inertia required for grid system security. The batteries would not be required if these forms of generation were a plug-in replacement for real, conventional generation.

The batteries then are a necessary 'band-aid'. That they are required as a band-aid does not justify the requirement for the vast land-grab that will result from their use. The battery unit itself is NOT a "renewable", or any other form of, generator.

Also, policymakers need to understand, for this renewables plus battery storage scenario to even begin to be a feasible option:

1. that the battery storage cannot simply be added incrementally over a period of time from some low starting value. It must be available as the amount as stated, that is, 12,077,136 MWh minimum, and it must be fully charged at the time of switch-over to 100-percent renewables.
2. that the renewables complement must be at the level as stated before shutting down any of the remaining dispatchable generation.

Attempting to shut down existing dispatchable, fossil-fuelled generation before the above capacity requirements are met, in full, will merely lead to frequent, unpredictable, widespread blackouts.

Policymakers also need to consider the following:

1. Neither the required units of renewable generation nor the battery storage units "grow on trees" or "pop out of thin air". At present, all such units are fully imported, increasingly from suppliers whose intentions toward Australia are recognised by Australia's Security Services as being rather less than benign. At any time, these suppliers could impose a trade embargo on the supply of this equipment, instantly posing a profound risk to National Security. See also Wilson (2023).

2. Each Geelong-scale Big Battery will occupy the space, involve the land take, as quoted above, of an AFL football stadium, and then some. Where and how are some 46,000 Geelong Big Battery equivalents going to be sited?

3. What considerations have been given to the transmission line requirements to connect so many of these grid-scale batteries to the Eastern Australian Grid?

4. Where are these grid-scale batteries to be manufactured? What amount of CO_2-producing fossil-fuels will be required to mine the ore, extract, refine and manufacture, the enormous number of battery modules required?

5. Given the massive scale of the battery requirement, and the known probability of risk of fire, the provision and cost thereof of permanent firefighting facilities and staff, similarly on a massive scale, must be factored into the operations of these battery storage units.

Exclusions from this analysis

The requirement to replace the Synchronous Inertia automatically provided by conventional, fossil-fuelled generation has been mentioned in the Executive Summary. However, any Battery Storage Requirement to address this need is not the subject of this analysis. That is, any Battery Requirement to supply such as the "Grid-firming" or "Synthetic Inertia" substitute for the Synchronous Inertia requirement is in addition to the storage requirement identified here.

To give some indication of the battery storage requirement for grid-firming, the AEMO (2024, pp. 12) has identified a need for some 49 GW/646 GWh of firming storage, as part of a total of 75 GW (AEMO, *ibid*.,pp. 73). Using this AEMO estimate as a guide, the figure of 646 GWh corresponds to some 1437 Geelong Big Batteries. This requirement is in addition to the findings determined by the analysis discussed here, which is the long-term storage requirement alone.

Ashworth & Pashajavid (2025) provide a useful primer on the concept of "grid-firming".
A paper prepared for Transgrid (2024) provides a very comprehensive technical review of the state of development of grid-firming technologies. What is very clear from this paper is that:

- The battery systems used for grid-firming are considerably more expensive than those grid-scale BESS systems used for energy storage;

- It is by no means the case that the grid-firming technology that is presently available can be regarded as reliable and system-ready. See: "Table 7-1: Comparison of synchronous generators and GFM inverters from a grid-support standpoint", (Transgrid, *ibid*.) for a useful summary of the present state-of-the-art of Grid-Firming technologies.

Introduction

Menton (2022), addresses the battery storage problem in a readily-understandable paper. He states: "*Remarkably, none of the jurisdictions currently embarked on crash programs to implement Net Zero through wind and solar facilities has paid much attention to the energy storage problem. All appear to assume that one only needs to build enough wind turbines and solar arrays, and perhaps a few batteries of unspecified amounts along the way, and the fossil fuel facilities can just gradually be retired and emissions will fade away. As we will see, the energy storage problem is enormous, it is critical, and it is far from being solved.*"

Subsequently, Menton (2023) , discusses a scholarly paper by a certain Balazs Fekete and colleagues (Fekete B *et al.*, 2023), and a blog post article by Fekete himself (2023), discussing their experiences in getting the paper published. In the paper, Fekete *et al* (*ibid*.) concluded, for the fairly large region of the US that they considered, comprising 18 adjoining northeastern States, that a value of storage, equivalent to some 25 percent of the total annual demand for that region, is the minimum requirement. On an average demand basis, this 25 percent is equivalent to some 91.25 days of demand.

Putting that into the Eastern Australian context, 25 percent of annual demand for the year 2023, based firmly on AEMO operational data, this being some 20,970 MW (the average annual demand for 2023), times 24 hours/day times 365 days/year times 25 percent, or, 45,924,300 MWh.

To put that number into some sort of real item of equipment, that is the equivalent of 102,054 Geelong Big Batteries. (The Geelong BB has a stated storage capacity of 450 MWh.)

Clearly, these are enormous numbers, implying an enormous and unprecedented infrastructure requirement, the like of which has never been attempted in Australia, if indeed anywhere.

To seek to put the likely requirement into the context of the Eastern Australian grid, I thought to apply the analytical method described by Fekete *et al (ibid.)* to the Eastern Australian grid, where, instead of having to deduce likely electricity generation performance from regional wind behaviour and solar irradiance characteristics, as Fekete *et al (ibid.)* were, it seems, required to do, presumably because they did not have access to electricity performance data for their region, I could use directly the publicly-available, actual AEMO-supplied operational data, thus hopefully removing a significant source of uncertainty in the results from the analysis.

The first step was to sub-total, respectively, the hydro, wind farm, and solar farm data, from the AEMO's NEMWEB site at every 5-minute timepoint from the years 2023, 2024, Dispatch_SCADA data. I also collected the AEMO's Operational Demand and estimated Rooftop PV data for 2023-4. Each of these latter datasets is supplied at 30-minute timepoints, so I presumed to interpolate these values to the intermediate 5-minute timepoints. This approach allowed the use of the Fekete *et al (ibid.)*. methodology at every 5-minute timepoint.

Note: I did not include pumped-hydro in the hydro subtotals. At present, the operators of pumped-hydro plants are not constrained to purchase the pumping component from renewables' sources, so I have presumed that these sources provide what is essentially delayed fossil-fuel generation.

Methodology

Essentially, as I understand it, the Fekete *et al (ibid.)* methodology is applied in the following way:

(a) At the first, or earliest, timepoint in the series of interest, sum the renewables' subtotals (MW), subtract the corresponding demand (MW), the result is the deficit/surplus value at that timepoint.
(b) Convert this deficit/surplus value to MWh, noting that the time period is 5 minutes, and store it as the accumulated deficit/surplus.
(c) Repeat at the next timepoint, but for this, and successive timepoints, add the surplus/deficit from each previous timepoint. (Where it is understood that to "add" is an algebraic addition: a deficit carries a minus sign, so, "adding" a deficit value is essentially subtracting it).
(d) Continue in this fashion, recording the deficit/surplus value at each timepoint, and accumulating a total deficit/surplus value across the entire time span of the operational data.

This process, as Menton (*ibid*.) observes, is very similar to the procedures used in normal financial profit and loss accounting. It is important to mention “deficits” because, at present, given that the renewables capacity on the Eastern Australian grid is still far short of being able to supply the present demand requirement, running this accumulation process with the current values of the renewables’ subtotals quickly results in a very large, negative value, that is, a large deficit, and hence a failure to supply sufficient generation to meet demand.

Before attempting the analysis, it is useful to attempt to place limits on the various likely values, where that is possible. For example, what might be the maximum possible value of the Required Storage, presuming the absolute worst-case conditions?
As the lower limit, the Required Storage cannot be less than zero.
Presumably, the absolute maximum value might be that required to meet one year’s Demand. (It may safely be presumed that having all forms of generation shut down for more than a year, which is what this value implies, would be deemed to be totally unacceptable.)
This value is readily determined: Average Demand (MW) times 24 hours times 365 days per year, Inserting the value for Average Demand for calendar years 2023-2024 in the equation:
20966.7409399774 MW times 24 times 365 MWh per year, resulting in a value for the upper limit of the maximum Required Storage of: 183,668,651 MWh (per year).
The range for the value of the Required Storage that would meet the variations in the Total Demand during one year, must lie somewhere within the range: [0 - 183,668,651] MWh.

To attempt to study what would be a likely 100 percent renewables configuration, I thought to run a number of different scenarios where, in each, in turn, I multiply the present wind and solar sub-totals by a positive number, starting at two, and then calculate the accumulation for the entire period (all 5-minute time points for 2023-2024). If that multiplier produces a negative value for the running total of the accumulation – signifying a blackout - then increase that multiplier number and repeat the deficit/surplus calculation for the entire period. Repeat as necessary, increasing the multiplier for each scenario attempted until an overall surplus – no negative values in the running accumulation - results. To give some sort of context, the first, the “multiply-by-two” scenario is equivalent, to a first approximation, to doubling the installed wind and solar farm capacity. Unsurprisingly, this scenario also results in a large deficit, but it is not as large as the first case.

Note: in devising this strategy, I chose not to use multipliers on the Hydro and Rooftop PV subtotals for the following reasons:

i. given community attitudes regarding hydro dams, it is extremely unlikely that there will be a significant increase in hydro capacity in the foreseeable future,
ii. Rooftop PV capacity is already so large that it is straining grid stability limits in the middle of the day on almost every day, so it is extremely unlikely that even a doubling of capacity, for example, would continue to be actively encouraged by government policy. (Also, the figures provided by the AEMO for Rooftop PV performance are an estimate only.)

In an earlier version of this work, I sought to commence the stepwise process with a Storage of zero, hoping to build it up over time to some sort of steady-state by starting with a sufficently large multiplier of the current renewables' generation portfolio.

It soon became apparent that this methodology failed, in that a very large initial portfolio of renewables-only generation was required, resulting in the situation that, without reducing the multiplier over time, the amount in storage just kept increasing monotonically.

I thought to look at other possibilities, first doing a search of the hydrology literature on such as: "sizing reservoir storage to match demand". I found the following, potentially useful, link: "https://engineeringnotes.com/water-engineering-2/storage-resevoir/how-to-determine-capacity-of-a-storage-resevoir"
Two methods were described, the second being what is called the "Mass Curve method". What became clear here was that, in order to determine the required storage, in any run, the initial storage in the reservoir must be such that, on commencing the march through the timesteps during, for example, one calendar year of 5-minute timesteps, the reservoir must be at full capacity.

A first step to a "Real" Battery Scenario

As it is of absolute importance to obtain the best estimate of the storage requirement, I thought to give due consideration to the very real losses in using battery storage. As a first step to including these losses in any practical battery storage configuration, I thought, from the outset, to consider the case of the "non-ideal" battery. In a recent email citing a paper at: https://www.windtaskforce.org/profiles/blogs/battery-system-capital-costs-losses-and-aging, Post (2019) cites the following recommendation from Tesla, the manufacturer of the Hornsdale "Big Battery" in South Australia, that to maximise battery life:
"*The 40% throughput is close to Tesla's recommendation of 60% maximum throughput, i.e., not charging above 80% full and not discharging below 20% full, to achieve a 15-y[ear] life, with normal aging*". See also Post (*ibid*.) for a comprehensive discussion of grid-scale battery losses.In determining the accumulating storage then, I needed, at the very least, to ensure that at all times that:

- the resulting value for the Required Storage was set at 1.25 times the maximum accumulating storage, (thus ensuring that the accumulating storage never exceeded the battery manufacturer's requirement that 80 percent of the actual storage is never exceeded),
- at any time point, the amount of the storage component available to calculating the deficit/surplus was never such that the residual in the battery storage was permitted to fall below the stipulated 20 percent of the current Required Storage capacity.

What became clear from the use of the hydrologist's methods is that any iterative attempt at predicting the required storage must presume that the chosen storage is at full capacity at the commencement of the iterative procedure.
Also, it seemed sensible to chose an initial value for the multiplier/s such that the average value of the total available renewables-supplied generation, (that is, wind plus solar far plus Rooftop PV plus

hydro), is equal to, or just slightly greater than, the average demand for the period under consideration, here the calendar years 2023-2024.

Results

In summary, after trialling many iterations using different multiplier values on the present respective wind and solar installed capacities, I found that the multiplier 3.31, applied to both these current wind farm and solar farm complements, was the minimum required to enable the mix to meet the present demand. The use of this generation mix resulted in a storage requirement equivalent to 41.1 days of average demand. This requirement, remembering that the total storage required is 1.25 times the actual storage required to balance the demand, (given that the storage may be filled to no more than 80 percent of capacity), came to some 20,625,000 MWh. This then is the storage required to be able to balance demand at all times throughout calendar years 2023-2024.

Giving some sort of context to what this bare number, some 20,625 GWh, means:
it corresponds to 45,833 Geelong Big Batteries, or, 159,884 Hornsdale Big Batteries.
It is useful to compare the latter with an estimate by Paul McArdle, CEO of Global-ROAM Consulting), which I understand is some 70,000-80,000 Hornsdale Big Batteries (Moran, A., *pers. comm.*). But I further understand that Mr McArdle presumed, as a reasonable first approximation to obtaining a ball-park figure, that the batteries are "ideal"; that is, he did not attempt to address such practicalities as, available storage vs the required storage, transmission losses, two-way trip losses, redundancy required based on battery failure frequency, etc. According to Post (*ibid*.), the Hornsdale Big Battery has a storage capacity of 129 MWh.

The inclusion of any of these many other very real sources of energy losses in the round-trip from generation of surplus through to battery storage to subsequent supply to meet the demand at those times when there is a deficit in the renewables' output merely increases the required battery storage.

There are several, extremely serious, implications resulting from these findings.

1. Impact on CO_2 emissions reductions calculations – the Embedded Emissions

With this vast requirement of some 46,000 "Geelong Big Batteries", there is a clear requirement on the authorities that they determine an accurate estimate of the CO_2 emissions resulting from the mining, milling, refining, manufacture of the colossal amounts of materials required for the production, transport and site preparation for this huge number of required "Big Batteries". That the resulting CO_2 emissions might occur in countries outside of Australia does not excuse the requirement for the necessary accounting. It does not matter what is the site of their release, any resulting CO_2 emissions are being released into the Earth's atmosphere.

2. Recycling Burden

Any realistic estimate gives a battery lifetime of some 10-15 years at most. How will it be possible to develop efficient, both in materials and energy efficiency, and effective, recycling and re-use regimes to process such horrendous quantities of waste battery materials? Uttering pious words that "a circular economy will be developed" with no thought as to the detail, as NSW Planning, for example, is doing at the present time, is merely a strategy of leaving the resolution of these horrendous problems to future generations. For a realistic estimate as to the extent of the waste disposal issue, see Mills (2020).

3. Environmental Impacts

Given that the Geelong "Big Battery" requires a land-take that is at least equivalent to that of one of Victoria's Australian Rules Football Stadiums, there is an urgent need to address the likely environmental impacts of what is, by any estimation, a huge land-take requirement. Also worth emphasising is that there can be no argument as to land-use of the land-take required for a BESS. These behmouths occupy the entirety of the land on which they are constructed. There is also the land take required for the enormous amount of overburden and waste rock generated by the mining and milling operations required in the winning of the necessary materials required for the batteries. Again, see Mills (*ibid*.).

4. Fire Risk

At present, various EIS reports for BESS proposals usually emphasise the risk of fire damage TO the proposed BESS facility from bushfires. There seems to be no account taken of the likely damage to the vicinity of any BESS resulting from fires that start within the facility itself. That there is a very real risk of fires starting in these facilities during, say, a fast-charging scenario, seems at present to be almost totally ignored in these proposals. That there is such a very real risk is indicated by the high rate of fires occurring in domestic premises resulting from the presence of active, in-use batteries of the same Lithium-Ion technology. To think that such a level of risk can be ignored when of the order of 46,000 Geelong Big Batteries is the requirement, is simply fanciful.

5. National Security Concerns

As each of these "Big Battery" installations takes up a huge area, poses a significant fire risk due to the Lithium-ion technology used, and that there will be potentially so many of them, these big batteries constitute a very real National Security risk. It is not inconceivable that a determined aggressor, using something as simple as a concerted drone attack, could set out to destroy these installations, resulting in Eastern Australia a firestorm that would make, for example, the fire-bombing of Dresden during WWII, look like a village bonfire in comparison. That a grid-wide blackout resulting in the total paralysis nationally for some weeks would be the inevitable result of such an attack seems to be an almost incidental consequence. There is also the very real risk that a cyber attack on any potential "back-door", built in by foreign suppliers, could be used to shut down the batteries instantly, at any time, producing widespread blackouts. Why have governments seemingly given no thought to the likelihood of such a scenario? See, for example, Prins *et al* (2024) for a UK perspective of the likely devastating impacts on National Security that so-called "Net Zero" policies are already causing and increasingly will have in Britain. For the Australian context and perspective, the excellent paper by Wilson (*ibid*.) is recommended unreservedly. This paper not only discusses the, entirely negative, impacts of the present policies supporting renewables in Australia, it also provides a foundational basis for the meaning of Energy Security.

Conclusions

This initial analysis indicates that something of the order of the equivalent of some 46,000 Geelong "Big Batteries" will be required to even begin to address the storage requirements of a 100-percent Renewables scenario for the Eastern Australian grid at present electricity Demand requirements.

This is the amount of storage required to support what I think is a minimum complement of renewable generation that might replace the dispatchable, fossil-fuelled, generation fleet. The complement that I have chosen is some 3.31 times each of the present solar and wind farm fleets, plus the present hydro and rooftop solar complements.
I emphasise that the chosen combination is by no means the "only" one that might be used – many different combinations might be chosen. Cost considerations, might well suggest a different mix.

What has become clear is that, for example, if the desire is to reduce this massive amount of required storage, then a mix that is a massive overbuild of solar and/or wind generation might be used, but this would result in long periods of curtailment,-hence loss of potential income - something that might not be attractive to potential developers.

This figure of 46,000 does NOT address the round-trip losses necessarily resulting from the generation, storage, and later release of electrical energy from that storage. Accounting for these very real losses would merely increase the required battery storage figure.

This number of "Big Batteries" resulting from this very preliminary stage of my investigation indicates the requirement for some very serious investigative work, as a matter of extreme urgency, by those in authority who are presently forging ahead with the "100-percent Renewables plus Battery Storage" policies.

It is instructive, I think, to quote from the paper of Fekete *et al* (*ibid*.), where they summarise the outcome of their extensive literature search on the topic of the need for the requirement for backup and/or storage to support intermittent renewable generation:

"*Perhaps the most disturbing statement was "Many studies suggest that large (>50%) CO2 emission reductions will not be possible without carbon capture and sequestration (CCS)" (Loftus et al., 2015; Craig et al., 2017) citing the "Deep Decarbonization Project" (https://ddpinitiative.org). If this is a prevailing sentiment among researchers studying the viability of transitioning the energy sector to renewables, one would wish that they were louder and clearer several decades and trillions of dollar investments ago and informed the public that renewables are not sustainable since they will always require the assistance of fossil fuels.*"

Similarly, as far as I am able to determine, no relevant Australian government authority has performed and made publicly available any analysis that provides any indication whatsoever, in a readily understandable way, such as how many "Big Batteries" will be required in Eastern Australia, how they will be sourced and paid for, what are the energy requirements for their production, the waste disposal and CO_2 emissions resulting therefrom, where these batteries will be sited, and, given their relatively short service life, how they will be recycled and re-used.

It beggars belief that none of this absolutely necessary preliminary, investigative work seems to have been addressed by the relevant Australian Planning Authorities.

Pursuing the grand dream of "Renewable Energy Superpower" for Australia is, to quote Mills (*ibid*.), "*an exercise in magical thinking*". Given that electricity prices continue to spiral ever upwards[2], as a result of the ever-increasing level of subsidy payments to the ever-increasing fleets of so-called "renewables" and BESS storage; and the now looming threat of widespread, frequent blackouts; it is time that governments abandoned this nonsensical policy.

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[2]See, for example, a recent report: Cranston M 2025 *A survey of more than 500 Australian companies has found energy costs have become the top business challenge.* The Australian, 3 October 2025. Available at: https://www.theaustralian.com.au/business/a-survey-of-more-than-500-australian-companies-has-found-energy-costs-have-become-the-top-business-challenge/news-story/be7c2e1efbf7034fc78456dcab357b3b

References

AEMO 2024 AEMO Integrated System Plan For the National Electricity Market - A Roadmap for the Energy Transition. Available at: https://www.aemo.com.au/-/media/files/major-publications/isp/2024/2024-integrated-system-plan-isp.pdf?rev=b811f5d66df24e0a980ce0df8eaa5687&sc_lang=en

Ashworth P, Pashajavid E 2025 *Explainer: what does it actually mean to 'firm' renewables?* pv magazine February 2025. Available at: https://www.pv-magazine-australia.com/2025/02/12/explainer-what-does-it-actually-mean-to-firm-renewables/

Fekete B M 2023 *Net-Zero Targets: Sustainable Future or CO2 Obsession Driven Dead-end?* Available at: https://judithcurry.com/2023/11/14/net-zero-targets-sustainable-future-or-co2-obsession-driven-dead-end/ .

Fekete B M, Bacsko M, Zhang J and Chen M 2023 *Storage requirements to mitigate intermittent renewable energy sources: analysis for the US Northeast.* Front. Environ. Sci., 11, September 2023, 1076830. Available at: https://www.frontiersin.org/articles/10.3389/fenvs.2023.1076830/full .

Menton F 2022 The Energy Storage Conundrum The Global Warming Policy Foundation Briefing Paper #61. Available at: https://www.thegwpf.org/content/uploads/2022/11/Menton-Energy-Storage-Conundrum.pdf

Menton F 2023 *Another Critical Thinker Reaches The Obvious Conclusion: Intermittent Renwables Can't Work On Their Own. Available at:* https://www.manhattancontrarian.com/blog/2023-12-3-another-critical-thinker-reaches-the-obvious-conclusion-intermittent-renewables-cant-work-on-their-own.

Mills M 2020 *Mines, Minerals, and "Green" Energy: A Reality Check*. 9 July 2020. Available at: https://media4.manhattan-institute.org/sites/default/files/mines-minerals-green-energy-reality-checkMM.pdf .

Post W 2019 The Hornsdale Power Reserve, Largest Battery System in Australia. Available at: https://www.windtaskforce.org/profiles/blogs/the-hornsdale-power-reserve-largest-battery-system-in-australia.

Prins G, Kalghatgi G, de La Bedoyere 2024 *The Music Stops - Net Zero and National Security.* Available at: https://static1.squarespace.com/static/656f411497ae14084ad8d03a/t/65e18dad4b06fa0c5606a719/1709280690938/Prins-Music-Stops.pdf .

Transgrid 2024 Advice on the maturity of grid forming inverter solutions for system strength Available at: https://www.transgrid.com.au/media/diyb5fng/2403-aurecon_maturity-of-grid-forming-inverter-solutions-for-system-strength.pdf

Wilson S 2023 *Energy Security is National Security – A Framework for Better Energy Outcomes in Australia. Institute of Public Affairs.* Available at: https://ipa.org.au/publications-ipa/research-papers/energy-security-is-national-security-a-framework-for-better-energy-outcomes-in-australia, as: https://ipa.org.au/wp-content/uploads/2023/10/IPA-Research-Energy-Security-is-National-Security-A-framework-for-better-energy-outcomes-in-Australia-October-2023-FINAL.pdf.

Appendix – Comparison with Case Studies by Others

First scenario

In a recent post at: https://joannenova.com.au/2025/09/monday-124/, contributor Willoughby, (pseudonym "RickWill"), at comment #21.1.1.1 cited a paper, Willoughby (2017)[3], in which he had obtained for a figure of 250 GW installed solar generation, (as stated in the paper, this represents a massive overbuild of generation capacity), a requirement of some 750 GWh of storage.

I thought it would be useful to attempt to recreate this scenario using the Fekete *et al* (2023) methodology described here.

In the paper cited at the first post above, Willoughby assumes the use of an ideal battery. That is clear from the several figures in the paper as the battery discharge/charge characteristics are shown as going from the full 100-percent charge state to 0-percent discharge state.

I thought to run this scenario staying with the use of a non-ideal battery as I believe that this is a better reflection of reality. Interestingly, and perhaps surprisingly, for an installed solar capacity of 250 GW, the Fekete *et al* (2023) analysis methodology yields a battery storage requirement of 987 GWh. Given that this is for the use of a non-ideal battery, where the battery state of charge may never exceed 80-percent of battery capacity, nor drop below 20-percent capacity, this figure of 987 GWh can be considered to be comparable to the Willoughby (*ibid*.) figure. (A non-ideal battery requires a significantly higher total capacity in order that the charge swing between the permitted 80-20-percent limits is sufficient to give the required storage.)

In addition, I thought it might be useful to determine the required storage for a range of values below the cited 250 GW installed solar capacity proposed by Willoughby (*ibid*.) to see how the required storage might vary with a given installed capacity. The following table shows the results.

Installed Capacity (GW)	Required Storage (GWh)
80	26735
96	14750
120	6213
140	2538
160	1725
200	1375
250	987

As can be seen from the table, the required storage rises dramatically as the installed solar capacity is reduced. The required storage value of 26735 GWh listed in the table for the lowest installed capacity figure of 80 GW compares favourably with the value of 20625 GWh which I found for the mixed generation scenario discussed in the analysis in this paper, remembering that, similarly, this figure of 80 GW is a much lower overbuild in installed generation capacity.

[3] Willoughby 2017 *Meeting Unscheduled Demand with Intermittent Generation – Submission to the Independent Review into the Future Security of The National Electricity Market* 19 February 2017. Available at: https://www.environment.gov.au/submissions/nem-review/willoughby.pdf

Second scenario

Subsequently, at:
https://joannenova.com.au/2025/10/trump-goes-gangbusters-on-beautiful-clean-coal-more-land-more-mines-and-625m-to-reopen-old-plants/, at comment #9, Willoughby cites a quotation from a wind farm developer which states:

"*The Australian Government has set a 2035 emissions reduction target at 62–70% below 2005 levels. Hitting this target will require a massive scale-up of renewables: 4x wind capacity, 3x utility solar, 2x rooftop and distributed solar, and 6x utility-scale storage*."

As this is a quote from a wind farm developer, it deserves little credence. However it is useful to run the analysis using the multipliers cited, noting that as at 30 September 2025, it is reported that there is some 6,591.5 GWh installed BESS capacity on the Eastern Australian Grid[4]

Running this particular scenario gives a storage requirement of some 12,640 GWh, which is some 1915 times the presently-installed BESS storage; a figure that is rather more than the "*6x present utility-scale storage*" capacity as quoted above.

This second result does rather confirm the view expressed at the outset that government authorities in Australia have yet to do any sort of serious analysis as to what mix of generation and storage would be required on a renewables plus storage -dominated Eastern Australian Grid.

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[4]Heynes G 2025 *Australia's NEM battery storage surpasses 6.5GWh milestone in week*. September 2025. Available at: https://www.energy-storage.news/australias-nem-battery-storage-surpasses-6-5gwh-milestone-in-weekend-of-records/