<u>Objection Submission regarding 'Virtual Power Plants to Compete with Big Generators to Drive Down Prices.'</u>

The Australian Energy Market Commission (AEMC)is failing at every turn to provide the ESSENTIAL SERVICE of a reliable, affordable, secure electricity system for the people of Australia.

<u>AEMC/AER/AEMO'S ongoing failure isn't a glitch, it is a design feature - based on</u>

"confection ….. made up evidence - so lacking in integrity that no weight can be placed on it!' (Federal Court Judge Justice Natalie Charlesworth - NT Santos Barossa Gas deal - dismissed EDO Appeal - 15/1/24)

To quote AEMC:-

'The Australian Energy Market Commission (AEMC) has released a draft paper that proposes allowing Virtual Power Plants (VPPs) to compete directly with large-scale generators in the energy market, to the **benefit of all consumers through significant cost savings, lower emissions, and reduced energy prices.**

The draft determination also extends beyond VPP's to include community batteries, flexible large loads, and other price-responsive small resources such as such as back-up generators, marking a significant shift in Australia's energy landscape.

AEMC Chair Anna Collyer said this work represents a pivotal moment in our energy market's evolution.

"By integrating VPP's and similar resources, we're not just **enhancing market efficiency; we're empowering consumers and paving the way for a more sustainable energy future,"** she said.

Currently, there is no mechanism for the market to predict how these resources will respond to daily price fluctuations.

This gap in market knowledge creates significant operational challenges for the Australian Energy Market Operator (AEMO) and could lead to costly system operations.

"Fully integrating these resources will allow energy, security, and reliability services to be provided more efficiently," explained Ms Collyer.

"Over time, this integration will reduce the need for large scale generation and storage infrastructure, **ultimately decreasing costs and emissions for all consumers."**

I DO NOT CONSENT to AEMC presiding over & deliberately orchestrating a Fake Green RenewaBULL Energy Poverty Grift & Ponzi Scheme/Scam - a Brazen Deception, a Predatory System designed to undemocratically & sneakily take over regulatory control of all private systems AGAINST OUR WILL - WITH NO SOCIAL LICENCE - solely due to their inept, non-sensical lack of capable, actual storage - with the express purpose of sneakily gaining

Price Protection for Destructive, Pathetic Industrialised Solar Traders - whilst ripping off & torturing us electricity consumers in the process & intentionally excluding the private costs from their plans.

This lunacy has NO INTEGRITY OR ETHICS & IS NOT BASED ON REPUTABLE ENGINEERING FACTS OR SCIENTIFIC RIGOUR.

None of AEMC Chair - Anna Collyer's claims will ever be TRUE - including:-

***<u>NOT</u> "benefit of all consumers through significant cost savings, lower emissions, and reduced energy prices."**

<u>NOT</u> "enhancing market efficiency; we're empowering consumers and paving the way for a more sustainable energy future."

<u>NOT</u> "Fully integrating these resources will allow energy, security, and reliability services to be provided more efficiently,"

<u>NOT</u> "ultimately decreasing costs and emissions for all consumers."

<u>DEMAND MANAGEMENT - AEMO are Paying Big Users to Turn Off & Stand Idle - the ONLY way we aren't having BLACKOUTS!!</u>

AUSTRALIAN PEOPLE ARE RIGHTFULLY DEMANDING OUR OWN SUPERIOR, RELIABLE, AFFORDABLE, SECURE, 24/7 AUSTRALIAN BASE-LOAD POWER WITH MINIMAL ENVIRONMENTAL FOOTPRINT INSTEAD.

****AN IMMEDIATE MORATORIUM & AUDIT OF ALL REGULATORY AUTHORITIES AEMC, AER, AEMO, ALL ELECTRICITY GENERATING WORKS & NETWORK SUPPLIERS/OPERATORS IS ESSENTIAL - TO ENSURE CRITICAL ENERGY INFRASTRUCTURE CONTROL, SUPPLY & DISTRIBUTION MEETS ALL OBJECTIVES OF THE NATIONAL ELECTRICITY LAW & THAT ASSOCIATED BODIES ARE NOT**

SUBJECT TO THE CCP's NATIONAL INTELLIGENCE LAW.

ALSO, THAT NO ENERGY COMPONENTS ARE ABLE TO BE REMOTELY DISABLED BY HOSTILE ENEMIES/BAD ACTORS.

STOP TORTURING US & WRECKING AUSTRALIA WITH YOUR EVIL, FAKE GREEN, CONTAMINATING SWINDLE!!

References:

****The Missing Whole-of-System Cost Model in the AEMO 2024 ISP:-**

"Recommendations

1. A thorough investigation by independent authorities and immediate implementation of effective accountability mechanisms must be implemented to counter the complete failure of public energy policy regarding reliability and energy costs based on misleading information from public institutions.

2. The AEMO ISP and CSIRO GenCost documents must be subjected to higher genuine standards for truthfulness, completeness and professional engineering processes in place of slavishly following flawed existing policies.

3. Embedding wind & solar targets into the National Electricity Rules must be halted to end the replacement of power systems engineers by politicians and government bureaucrats selecting technological design solutions without proper engineering qualifications.

4. Independent expertise for frequent technical and financial review must be employed in new accountability processes at multiple levels and points in time with a mandate to examine and openly examine a wide range of technological approaches.

5. The AEMO 2024 ISP must be discarded and an immediate start be made on a new energy NEM plan considering all power system technologies." (PDF Attached)

DEFIES NATIONAL ELECTRICITY LAW

AEMO, and everyone in 'authority', place primacy on emissions target rather than the other requirements of the NEL. The emissions requirement was only added to the NEL in Sep 2023, and the NSW Emissions Reduction Act 2023 was only passed in Nov 23 (other states were similarly tardy to legislate any targets), - so on what basis did any Gov act prior to that to impose all this on us? Yet they all did, and still emphasise emissions over other objectives. NEL is made in the SA Parliament, and in the 2nd reading, the minister there also reiterated that all objectives are equal.

Complete Inadequacy & Unsuitability of Incapable Battery Energy Storage Systems

Paul Miskelly's:-

****'Storage requirement for 100 percent Renewables on the Eastern Australian Grid - Initial Findings.'**

****'Validity of Claims by Renewable Energy Proponents re No. of Households Served by Proposed Generators.'**

****'Forever chemicals' used in lithium ion batteries threaten environment, research finds | Lithium-ion batteries | The Guardian**

https://www.theguardian.com/technology/article/2024/jul/14/forever-chemicals-lithium-ion-batteries-environment

****WIND TURBINES ARE A FAKE GREEN SCOURGE - SHEDDING TONNES OF MICROPLASTICS FROM WIND TURBINE BLADES (KNOWN AS 'LEADING EDGE EROSION') - AFTER ONLY A FEW YEARS OF OPERATION.**

Bisphenol A - a toxic chemical used in the epoxy resins that are used to make turbine blades. High speed spinning blades 300 KM/H collide with dust particles, rain and hail chipping off small particles of the resin coating.

https://stopthesethings.com/category/bisphenol-a-wind-turbine-blades/

https://bergensia.com/bisphenol-a-in-wind-turbines-damages-human-fertility/es-human-fertility/

****GROUND WATER SUPPLIES MUDDIED BY PILE DRIVING FOR THE MASSIVE WIND TURBINE BASES.**

Wind farm woes continue as Victorian turbines fail after only five years – www.cairnsnews.org - 11th April 2024

https://cairnsnews.org/2024/04/11/wind-farm-woes-continue-as-victorian-turbines-fail-after-only-five-years/

****Leaching Via Weak Spots in Solar Panels**

https://www.researchgate.net/publication/348883160_Leaching_via_Weak_Spots_in_Photovoltaic_Modules

****Degradation of Solar Panels - identified forms of degradation, degradation mechanisms.... out of control major source of environmental pollution!**

https://onlinelibrary.wiley.com/doi/10.1002/pip.3788

https://theconversation.com/as-the-world-heats-up-solar-panels-will-degrade-faster-especially-in-hot-humid-areas-what-can-we-do-221990

****Sediment Run-Off Contaminating Land/Water - Court Case -**

"Created, Operated, and Maintained a Nuisance"

Solar farm runoff pollutes property, couple awarded $135 million - CFACT

https://www.cfact.org/2023/06/06/solar-farm-runoff-pollutes-property-couple-awarded-135-million/

By Bonner Cohen, Ph. D. |June 6th, 2023

25th Oct 2023 update ...A federal judge has dramatically reduced a jury's $135 million award to a Georgia couple (https://www.ajc.com/news/couple-awarded-135m-after-solar-project-turns-their-lake-to-mud-hole/BZ6BYXQREJCDROQV6ZASUW5WOI/)

****Contamination from Industrialised Solar's Galvanised Steel Supports**

https://www.facebook.com/share/p/srbXaCbKgVXocgsm/?mibextid=xfxF2i

James Falcsik White County Indiana Residents Against Solar

21 h ·

****The 'Sunk Cost' Trickery That Makes Renewables Seem Cheaper Than They Are - 23rd July 2023.**

https://www.fresheconomicthinking.com/p/the-sunk-cost-trickery-that-makes?utm_medium=web

AIDAN MORRISON

How CSIRO justifies the exclusions: "Sunk Cost"

But wait, this deception is so brazen and transparent.......

All of these tens of billions of dollars of projects are explicitly excluded from the cost of integrating renewables.

****Unravelling AEMO's Integrated System Plan: World-class, Incompetent, or corrupt?**

https://youtu.be/mFcaZ0fgWzk

****Counting the Cost: Subsidies For Renewable Energy - The Centre for Independent Studies**

https://www.cis.org.au/publication/counting-the-cost-subsidies-for-renewable-energy/

****More misinformation from CSIRO on Nuclear**

https://www.cis.org.au/commentary/video/more-misinformation-from-csiro-on-nuclear-copy/

****Nuclear VS Renewables: What Will It Cost?** | Zoe Hiltonhttps://www.youtube.com/watch?v=Mw_AX9WaJ08

**Adi Paterson - You are being Conned

GenCON Report & equating AEMO & the Government with Animal Farm!

https://youtu.be/J50hWO2DKHc

**Energy Transition Masquerade: The $360 Billion You Pay - YouTube

https://www.youtube.com/watch?v=x0NKDozvO58

**Australia will emulate Sweden & Dump Net Zero Agenda - 8th September 2024

Sweden's conservative government has taken a bold step and reversed the climate taxes on flying & fuels introduced by its predecessors. This decision marks a significant departure from the previous climate agenda and represents a significant relief for the Swedish population.

Journalist Peter Immanuelsen reports that the Swedish government would also oppose the anti-cash agenda. This is another sign that Sweden is distancing itself from global agendas such as Klaus Schwab's.

“It's really a surprise that Sweden is suddenly doing so many things that run counter to Klaus Schwab's agenda. Five years ago, this was unthinkable. Good things are happening!" writes Immanuelsen.

With these measures, Sweden is sending a clear signal and showing that it is possible to oppose excessive climate and tax policies. The conservative government puts the interests of the citizens first and provides a noticeable relief in everyday life.

Kettner Precious Metals Magazine News Steer

08.09.2024 01�50 a.m.

Sweden sets an example: Abolition of climate taxes on flies and fuels introduced by its predecessors.

This decision marks a significant departure from the previous climate agenda and represents a significant relief for the Swedish population.

A change of course in climate policy:

After the Swedish government had already removed the goals of the 2030 Agenda....

Sweden's conservative government has taken a bold step and reversed the climate taxes, ... government programme, the CO2 tax on diesel and petrol has now been abolished.

This measure directly led to a decline in diesel prices and relieves the burden on low-income citizens in particular.

Now the climate tax on airline tickets has also been lifted, making flights more affordable again for Swedes.

Social action against inflation:

The abolition of climate taxes is seen as a direct social measure against inflation.

In countries such as Austria and Germany, where the CO2 tax on gasoline and diesel has already been introduced and is expected to rise further in the coming years, citizens are paying increasingly higher prices.

In Sweden, on the other hand, people are now benefiting from cheaper fuel and airfares.

Reactions and consequences:

Reactions to these measures are mixed.

While the Green Party describes the tax breaks as "irresponsible", many citizens are relieved.

According to estimates, flights outside Europe could become cheaper by more than 30 euros as a result of the abolition of the flight tax. This is a significant relief for travelers and could boost tourism.

From:

[redacted]

7 National electricity objective:

The objective of this Law is to promote efficient investment in, and efficient operation and use of, electricity services for the long-term interests of consumers of electricity with respect to-

(a) price, quality, safety, reliability and security of supply of electricity; and

(b) the reliability, safety and security of the national electricity system; and

(c) the achievement of targets set by a participating jurisdiction-

(i) for reducing Australia's greenhouse gas emissions; or

(ii) that are likely to contribute to reducing Australia's greenhouse gas emissions.

PARIS AGREEMENT

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

"(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."

Unreliable, Intermittent, Solar/Wind/BESS are NOT IN THE INTERESTS OF CONSUMERS - DEFYING NATIONAL ELECTRICITY LAW OBJECTIVES OF:-

***PRICE, QUALITY, SAFETY, RELIABILITY & SECURITY OF SUPPLY OF ELECTRICITY.**

***THE RELIABILITY, SAFETY & SECURITY OF THE NATIONAL ELECTRICITY SYSTEM.**

5 July 2024
The Hon. Paul Scully MP MLA
Member for Wollongong
Minister for Planning and Public Spaces
Parliament of NSW
E: wollongong@parliament.nsw.gov.au
E: office@scully.minister.nsw.gov.au

Dear Mr Scully,

Validity of claims by Renewable Energy Proponents re No. of Households Served by proposed Generators

Executive Summary

From an analysis of real generation data for an example solar farm, coupled with a reliable set of household consumption data, it is shown that the claims made as to households served and the scale of battery storage required for a particular proposed solar farm in NSW are, quite simply, considerably overstated. These findings beg the question as to how many other such proposals, perhaps already approved by Planning NSW and the Independent Planning Commission (IPCN), have made similar, untested, claims.

There are several important consequences of these overstatements by proponents.
1. To service a given expected level of Demand, always an essential metric for which to have a reliable estimate, if it is found in subsequent operation that proponents have wildly overstated the demand that their proposed generators might service, then either far more generators will have to be built, posing significantly increased environmental and social impacts, destruction of valuable farmland, etc., or, where not addressed, massive Statewide power shortages will be the inevitable consequence.
2. Addressing any serious shortfall in battery storage would require a massive increase in the number of BESS installations, resulting in similarly vastly increased social and environmental impacts, and a massively increased fire hazard to surrounding regions, the latter resulting from the inherent safety issues endemic in the Li-ion battery technology itself.
3. Massively increased waste disposal issues resulting from the hugely increased resource requirements. It is to be kept in mind that solar panels do not last 25 years as claimed by proponents, and batteries, from the Hornsdale experience, have a service life of less that 10 years.

To give some idea of how far wrong the proponent is in its calculations, even with a battery storage equivalent to 450 Geelong Big Batteries, a number which would be impossible to fit into the selected site, the proponent’s solar farm can never supply 262,000 homes.

This poor performance needs to be considered in conjunction with such as the spectacularly poor performance of wind generation across the Eastern Australian grid during the present calendar year. Wind’s poor performance occurs frequently, if chaotically. In this background, to consider the further closure of coal-fired generation in the hope that wind plus solar generation plus battery storage will replace it is best described as an extremely dangerous policy.

Introduction

So often we see the claims in proposals for Wind and Solar Farms, or other such renewable energy facilities, that for any given proposal, the proponent claims that, it will “power so-and-so-many thousand homes”. How valid are these claims and how readily might they be checked?

I thought to examine one such claim and to provide my findings to you as the Minister responsible for the Planning Approvals process here in New South Wales.

The starting point for any such analysis is the obtaining of reliable data as to the average household consumption of electricity in NSW.

In searching for official data on household electricity and gas consumption, I found the publication by the Australian Energy Regulator (AER) entitled:
"*Residential Energy Consumption Benchmarks*", published on 9 Deccember 2020,
and available at:
https://www.aer.gov.au/system/files/Residential%20energy%20consumption%20benchmarks%20-%209%20December%202020_0.pdf

I have chosen data from that very comprehensive document for what the authors refer to as Climate Zone 5. See Table 16 on page 37. According to the preamble in section 4.2.4.Climate Zone 5:

"*The sample includes 1,908 households in Climate Zone 5. This includes 1,339 in New South Wales and 505 in South Australia. Climate Zone 5 covers several metropolitan areas including greater Sydney and Adelaide. The remaining 64 are in Queensland, in a small pocket to the immediat west of Brisbane.*"

I have chosen the Climate Zone 5 data as being representative of the household consumption patterns in the region of Eastern Australia in which the particular proposed project is to be sited. From that same Table 16, I have chosen the data as representative of households in NSW, that is, covering the wider region within which the proposed project is to be situated, and which therefore it is most likely to supply. Climate Zone 5 Table 16 data for NSW is reproduced below:

"*Table 16: Climate Zone 5: Electricity consumption benchmarks by household size (kWh)*"

State/Territory	Household size	Summer	Autumn	Winter	Spring
NSW	1	732	745	927	705
NSW	2	1,278	1,232	1,565	1,162
NSW	3	1,530	1,503	1,903	1,425
NSW	4	1,819	1,717	2,148	1,627
NSW	5+	2,158	2,082	2,761	2,007

For my analysis, I have chosen the line in the above table for a household of 4 persons. What I did was to use the seasonal average consumption of a representative household of 4 persons in conjunction with 5-minute AEMO SCADA data for a representative generator, scaled to match the specifications of a solar farm proposed here in New South Wales for a similar location.

Preliminaries

For this analysis, I chose the claims made by the proponent for the Birrawa Solar Farm, a proposal that is, I understand, presently before NSW Planning for consideration.
At the proponent's website: https://acenrenewables.com.au/project/birriwa-solar/
under the opening heading "The project", the following relevant claims are made:

1. "*It will generate enough energy to power approximately 262,000 average Australian homes.*"

2. "*The solar component of the project will have a capacity of around 600 megawatts (MW) and include a centralised Battery Energy Storage System (BESS) of up to 600 MW for 2 hours. The BESS will enable energy from solar to be stored and then released during times of demand.*"

The Issued Scoping Report at:
https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSD-29508870%2120211012T060833.452%20GMT
provides the further relevant information that, *"Birriwa Solar Farm which includes:*
🎬 the construction and operation of a solar photovoltaic (PV) energy generation facility with an estimated capacity of up to 600 MW; and
🎬 associated infrastructure, including grid connection and battery storage of up to approximately 1,000 MW (with an energy storage duration of up to four hours)."

From these statements I have presumed that: the Solar Farm is to have a capacity of 600 MW, and the Battery Energy Storage System (BESS) will have a capacity of 4000 MWh (1000 MW output times 4 hours).

Analysis - Ability of the Solar Farm plus BESS to supply the claimed number of households

It is an oft-overlooked fact, where renewables proponents discuss the performance of wind and solar generation in terms of average outputs, that solar panels produce no electricity whatsoever at night, all night, every night, 365 days per year, (includes leap year nights too!).

Any associated battery storage must therefore make up the supply shortfall, this being the full requirement of any power generated by the solar facility, for an average of 12 of those hours, at the very least, of every 24-hour day of the year, (the 12 hour period being an average value for the period commonly known as "night-time", or "darkness").

The proponent states that the proposed BESS has a storage capacity of 1000 MW times 4 hours, providing a potential maximum battery storage capacity of some 4000 MWh.
Presuming that the BESS battery is fully charged at any given sunset, and not allowing for losses, (which are indeed significant, and will be required to be fully accounted for in any detailed analysis), the question is: how many homes can the battery supply during the 12 hours of the night?

In any proper analysis, proponents must show, to satisfy the latter part of the second claim above, that the BESS battery will be able to supply the full Demand, required by 262,000 homes, during the full night time period, including long winter nights. That's the implied meaning of: "*The BESS will enable energy from solar to be stored and then released during times of demand."*

Any detailed analysis must allow that the hours of darkness for each day vary throughout the year, being a minimum at the Summer Solstice and a maximum at the Winter Solstice (which incidentally, for 2024, has occurred just prior to the writing of this document). In considering the worst-case scenario, on winter nights, the night-time period is significantly longer than 12 hours, even in New South Wales at the latitude of the proposed location for the Birrawa facility.

For this analysis, I have presumed that the period to be considered commences on 1 January 2023, and ends at 10 June 2024, so that the initial nights, the period of darkness is close to the minimum for the Summer, so, for the purposes of the analysis, is favourable to the facility's initial start state.

For generator data, I am using the real-time 5-minute generation data, publicly available from the AEMO, the operator of the Eastern Australian Grid, for the solar farm at Darlington Point New South Wales, which is listed by the AEMO as having an installed capacity of 245 MW. I have multiplied the output at each 5-minute data point by a factor of 2.182, (the multiplier being derived from the fact that as the stated capacity of the Birrawa solar generator is to be an installed capacity of 600 MW, then its output at any time, given that it is to be sited at a location not far distant from the Darlington Point facility in a similar climatic region, can be considered, to a first approximation, to be 600/285 times the output of the Darlington Point facility), and replaced it in the generator table.

The next step is, at each 5-minute timestep, to determine the Demand during that 5-minutes, resulting from 262,000 average Australian homes, in Zone 5 of the above table, each home comprising a 4-person household, these values varying as to the Season of the calendar year.

These Demand values are added to the generator table constructed above.

It is then a relatively simple matter to proceed to step through the table,

- determining the difference between the generator Supply and the Demand;
- adding (if a generation surplus) or subtracting (demand during the 5-minute period being greater than generator supply) the result from the current state of the BESS battery charge, terminating the process should the BESS battery charge state drop below 20-percent of rated capacity, or if not;
- repeating the preceding steps at the next 5-minute time step to re-run the calculation, until;
- the last 5-minute time step is processed, indicating that for the given time span, the solar generator plus BESS is able to satisfy the Demand imposed by 262,000 average Australian homes.

Limits: where the battery continues to discharge, the battery charge may not fall below 20-percent of the rated capacity (here 4000 MWh times 0.2 = 800 MWh), as such a state of discharge has a detrimental effect on battery lifetime. Where the battery charges, it may not charge to above 80-percent of full capacity, that is 3200 MWh. These then are the lower and upper limits of the battery's state of charge, (for the choice of these limits, see, for example, (Post, 2019).

Results

Commencing the run at 12:05 AM, that is, just after midnight on 1 January 2023, with an initial charge as the 80-percent limit, that is, 3200 MWh, the run terminated with the battery being discharged to its 20-percent limit at 2:05 AM on 2 January 2023.

This is a definitive result. A BESS of 4000 MWh capacity is incapable of supplying the Demand requirements of 262,000 homes for even 2 nights of the year 2023, at the height of the Summer months, when nights are shortest.

Conclusion 1 The above analysis shows that the claim by the proponent that the solar "farm", presuming that it has an installed capacity of 600 MW, that it will supply 262,000 average homes, can best be described as wildly optimistic.

This massive failure requires a clear explanation from the proponent showing, in detail, how the calculations were performed and what assumptions were used, to arrive at a number of 262,000 average Australian homes served.

It is tempting to re-run the calculation, decreasing the number of households each time until, if possible, a value for the number of households might be reached where the process is able to step through the entire time period under consideration, that is: 1 January 2023 – 10 June 2024.

I did repeat the process and found that the 600 MW Solar Farm plus 4000MWh capacity BESS battery is able to support some 22,500 average Australian households, that is, some 11.64 times less than that claimed by the proponent, so of the order of 10-percent of the proponent's claim..

I also chose a Battery Storage value of 200,000 MWh, which is a very large battery, being in fact the equivalent of some 450 Geelong Big Batteries, but even with this amount of storage, the combined system, addressing the Demand of 262,000 average Australian homes, fell over at 2023/04/18 02:35:00, that is, after some 3 and a half months operation. Clearly, where even using a battery storage that is so large, so gargantuan, that it is completely unachievable, also fails, then the claim that the proposed solar farm will serve 262,000 homes is in the realms of fairyland.

It is clear from this last run that the required demand simply runs down the initial battery storage, that is, in attempting to supply 262,000 homes, the solar farm is unable to recharge the battery sufficiently to any extent at all.

Conclusion 2 If the claim made by the proponent for the Birrawa Solar Project as to number of homes served is typical of the process being used generally by proponents of renewable energy projects that come before Planning NSW, then this analysis suggests that serious questions need to be asked about the assessment methods presently used, by both Planning NSW, and the Independent Planning Commission.

Yours faithfully,

Paul Miskelly
Moss Vale NSW
E: paul.miskelly@aapt.net.au

References

Round-trip battery efficiencies are mentioned in:
https://atb.nrel.gov/electricity/2023/utility-scale_battery_storage

Limits of Li-ion grid-scale battery charge/discharge:
Post, W 2023 *BATTERIES IN NEW ENGLAND TO COUNTERACT A ONE-DAY WIND/SOLAR LULL?* Available at:
https://www.windtaskforce.org/profiles/blogs/batteries-in-new-england

Post W *BATTERY SYSTEM CAPITAL COSTS, OPERATING COSTS, ENERGY LOSSES, AND AGING*. Available at:
https://www.windtaskforce.org/profiles/blogs/battery-system-capital-costs-losses-and-aging

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

Storage requirement for 100 percent Renewables on the Eastern Australian Grid - Initial Findings

Executive Summary - Notes for policymakers

As stated in the Conclusions below:
It would seem that Australian government authorities have not performed and 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 100-percent Renewables' Storage requirement, how they will be sourced and paid for, what are the energy requirements for their production, what are the waste disposal and CO2 emissions resulting therefrom, importantly, where these batteries are to 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.

The findings of this analysis are:

From an analysis based on the AEMO Operational Demand data for calendar year 2023, 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 24 days. This translates to a Storage Requirement of 12,077,136 MWh, equivalent to some 27,000 Geelong Big Batteries, or some 94,000 Hornsdale Big Batteries.

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.

Some 27,000 Geelong Big Batteries would occupy an area, a minimum area, of some 54,000 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, 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 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 the very necessary 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 (6).

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 are some 27,000 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.

Abstract

Francis Menton, in a recent article (1) , discusses a scholarly paper by a certain Balazs Fekete and colleagues (2), and a blog post article by Fekete himself (3), discussing their experiences in getting the paper published. In the paper, Fekete *et al* 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, is 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 year 2023 Dispatch_SCADA data. I also collected the AEMO's Operational Demand and estimated Rooftop PV data for 2023. 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*. 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 (1) 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 atempting 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 year 2023 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). 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 preiod. 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 resevoir 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 resevoir must be such that, on commencing the march through the timesteps during, for example, one calendar year of 5-minute timesteps,

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 very real 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 , Willem Post 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 (7) 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 iteritive 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 year 2023.

Results

In summary, after trialling many iterations using different multiplier values, I found that the multiplier 3.31 is required, with a storage requirement equivalent to 24 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), is 12,077,136 MWh. This then is the storage required to be able to balance demand at all times throughout calendar year 2023.

Giving some sort of context to what this bare number means -
it corresponds to 26,842 Geelong Big Batteries, or, 93,633 Hornsdale Big Batteries.

It is useful to compare the latter with an estimate by Paul McArdle, which I understand is some 70,000 -80,000 Hornsdale Big Batteries. But I further understand that Mr McArdle presumed, as a reasonable first approximation to obtaining a ball-park figure, that the batteries are "ideal": 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.

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 CO2 emissions reductions calculations

With a requirement of some 30,000 "Big Batteries", there is a clear requirement on the authorities that they determine an accurate estimate of the CO2 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 "Big Batteries" required. That the resulting CO2 emissions might occur in countries outside of Australia does not excuse the requirement for the necessary accounting: any resulting CO2 emissions are released into the same 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 (4).

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 (4).

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 30,000 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* (5) 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 (6) 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 30,000 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 figure of 30,000 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 <u>increase</u> 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* (2), 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 CO2 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 this grand dream of “Renewable Energy Superpower” for Australia is, to use a term of Mark Mills, “an exercise in magical thinking”. Put simply, it is time that this nonsense ceased.

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4 March 2024
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The Missing Whole-of-System Cost Model in the AEMO 2024 ISP

The Real Cost of the NEM Transition

A Report by Independent Engineers, Scientists and Professionals 31 July 2024

Summary

The government has not provided a true estimate of cost for AEMO's plan to transition the NEM to intermittent wind & solar, yet it claims adding reliable nuclear and gas power generation is too costly.

AEMO published its 2024 Integrated System Plan (ISP) in June. It contains only one paragraph[1] to indicate annualised capital costs as either $122 billion present value or $142 billion upfront present value, not including "commissioned, committed or anticipated projects, consumer energy resources, or distribution network upgrades". This unrealistic, poorly defined estimate needs much clarification.

The whole-of-system analysis in this report, draws on 2024 ISP capacities for generation and storages and CSIRO 2024 GenCost cost factors[2], and shows <u>total capital costs for the 2024 ISP over one trillion dollars for a system unable to deliver reliable power</u>[3]. This is about twice the capital costs of four alternative grid designs using gas, coal and nuclear. When fuel costs for gas and coal are considered, nuclear plus gas designs are likely to be the least costly of all options.

A More Comprehensive Capital Cost Analysis

The whole-of-system cost charts in Figure 1 below provide both total capital and present value for a more comprehensive model of the planned NEM grid transition, showing a present value more than four times higher than the 2024 ISP figures. Estimates include both CSIRO's somewhat optimistic declining future capital cost factors and its flat 2024 cost factors to reflect uncertainties in forecasting. The Baseline 2024 ISP estimates include all generation and storage costs including consumer energy resources, transmission lines, distribution network upgrades and other support costs to reflect the total costs to the economy.

Extending the Baseline ISP with additional gas or storage to overcome the major unreliability of the ISP's design incurs extra costs and makes clear that 'firmed renewables with batteries' is unaffordable. Four alternative designs using gas, coal and nuclear provide comparisons. The results, based on AEMO and CSIRO data, show that the present transition plan is the most costly approach by a large margin.

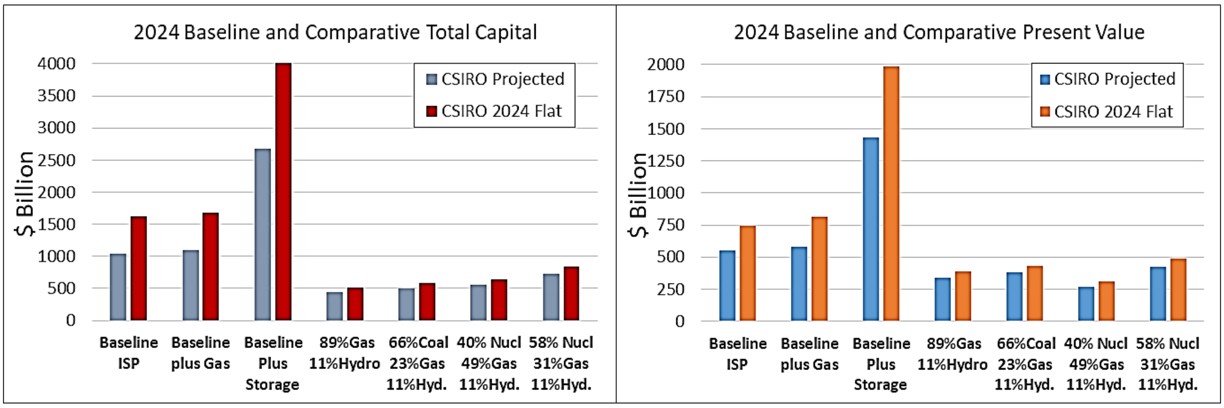

Figure 1 AEMO 2024 ISP Baseline and Comparative Whole-of-System Capital Costs in 2024 dollars

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[1] AEMO 2024 Integrated System Plan Page 74

[2] ISP Figures 2 and 20; GenCost Section 4.3;

[3] The 2024 AEMO ISP Will Not Deliver Reliable Power, Independent Engineers, Scientists and Professionals, 19 July 2024

Conclusions

1. Our analysis uses a proper high reliability systems engineering approach to assess a 24-hour cycle under worst-case conditions of maximum demand, wind and solar droughts and the need for a minimum 20% dispatchable reserve margin (DRM)[4] to guard against facility outages. A whole-of-system 'Baseline' power budget using 2024 ISP capacities shows the DRM at minus 19% by 2030 and falling much lower by 2040. Widespread and frequent blackouts are certain.
2. Adding battery storages and extra wind & solar to recharge them ('firmed renewables') to achieve 20% DRM overnight results in completely unaffordable total capital costs of several trillion dollars and provides storage for just one 16-hour overnight period. And it still leaves daytime DRM massively negative. Battery storage capacity for one week requires $5-7 trillion. Replacements every decade would cost upwards of $3.5 trillion. This is simply not a viable path.
3. Alternatively, adding gas to existing hydro to essentially duplicate the grid when wind and solar are in drought requires a not-insignificant additional capital cost of $30-60 billion. It would provide continuous backup capability, day and night, but its low utilisation rates would make its economics unattractive for investors.
4. The four alternative grid designs, 89% gas plus hydro, 66% coal plus gas & hydro, 40% nuclear plus gas & hydro, and 58% nuclear plus gas & hydro, provide reliable 24/7 power with less than about half the capital costs. The nuclear options, with lifetimes up to 80 years lasting far beyond 2050 compared with wind and solar, minimise costs for gas and probably reduce emissions to less than the Baseline ISP, once whole-of-life emissions for mining, processing and manufacturing of almost 900 times more material is taken into account. All four alternatives impose a tiny environmental footprint compared to the 1.6 million hectares for Baseline ISP wind & solar.
5. It is clear that contrary to continual claims that wind & solar are the cheapest form of electricity generation, it is in fact the most expensive when proper whole-of-system estimates are made. The present plan for transition of the NEM is disastrous in terms of reliability, cost to the economy and in particular to the environment, without being a path to the lowest emissions.
6. The alternative cost models assume wind & solar installations taper off after 2030. At additional cost, a small level of wind & solar (15-20%) can be maintained in the long term grid design.

Recommendations

1. A thorough investigation by independent authorities and immediate implementation of effective accountability mechanisms must be implemented to counter the complete failure of public energy policy regarding reliability and energy costs based on misleading information from public institutions.
2. The AEMO ISP and CSIRO GenCost documents must be subjected to higher genuine standards for truthfulness, completeness and professional engineering processes in place of slavishly following flawed existing policies.
3. Embedding wind & solar targets into the National Electricity Rules must be halted to end the replacement of power systems engineers by politicians and government bureaucrats selecting technological design solutions without proper engineering qualifications.
4. Independent expertise for frequent technical and financial review must be employed in new accountability processes at multiple levels and points in time with a mandate to examine and openly examine a wide range of technological approaches.
5. The AEMO 2024 ISP must be discarded and an immediate start be made on a new energy NEM plan considering all power system technologies.

[4] DRM is the sum of baseload power over maximum demand. In 2019 the DRM was plus 20% (AER)

Independent Engineers, Scientists and Professionals

This report has been prepared and supported by independent engineers, scientists and professionals who have many decades of relevant experience and requisite qualifications without any monetary conditions, employment or conflicting interests.

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Appendices

A Estimation Methodology

B Cost Model Notes

Appendix A Estimation Methodology

A. The AEMO 2024 ISP provides the data (Figures 2 and 20) regarding total NEM capacities of all generation (GW) and energy storages (GWh) in 2024-25, 2029-30, 2039-40 and 2049-30.

B. The CSIRO 2024 GenCost report (Section 4.3) provides projected capital cost factor data (in 2024 dollars) for various energy technologies. This data excludes of all subsidies, offsets and tax breaks, which nevertheless have to be paid by all consumers in one form or another.

C. Since the projected cost factors are largely declining and are based on forecasts which contains substantial uncertainties, a second estimate using flat CSIRO 2024 cost factors provides higher cost estimates reflecting potential upsides.

D. A power budget for each grid design model is based on a 24-hour cycle broken into 8 hours centred on midday when solar is available and 16 hours overnight when solar is essentially zero. The DRM is the surplus/deficit of the sum of baseload power over peak demand in each of the 8 and 16 hour periods. Stored energy is used only during overnight periods to contribute to dispatchable power; recharging takes place in daytime when solar is expected to be available but is also subject to weather conditions causing low outputs.

E. Except for the Baseline 2024 ISP model using only the capacities specified in the ISP, the capacity data for other models is adjusted to achieve a DRM in each period and year of at least plus 20% to ensure reliability in the face of facility outages.

F. The capital costs of Snowy 2.0 and Borumba pumped hydro facilities are taken from current government announcements. Costs of passive storages behind the meter are included because they lower demand while making no direct input to the grid.

G. The capital costs prior to 2024-25 are estimated using the 2024-25 ISP capacities and CSIRO 2024 cost factors.

H. The capital costs for each of three periods, 2024-30, 2030-40 and 2040-50 are estimated as the sum of the various generation capacities installed in each period plus the replacement for past installations that have exceeded lifetimes valued by the cost assumption for the mid-point of each period.

I. The modelled lifetimes are 10 years for batteries, 20 years for wind and solar, 30 years for gas, 50 years for coal and 80 years for pumped hydro and nuclear.

J. Costs for existing hydro facilities were not included in any models due to lack of data. Costs for existing coal plants were not included since they are near end-of-life and being retired.

K. The present value estimate is derived by applying a 7% per annum pre-tax, real discount rate applied to capital expressed in 2024 dollars in three periods: 2024-30, 2031-40 and 2041-50 at mid points.

L. The demand side participation (DSP) capacity derived by the 2024 ISP is not used since it is clearly not a source of power but rather a reduction in demand brought about by time-of-use tariffs and central controls to impose rationing on consumers. i.e. this misguided policy attempts to make customers serve a deficient grid design rather than the grid delivering power to consumers as and when required.

M. NEM peak demand is defined by AEMO's 2023 ESOO report for 10% Probability of Exceedance (POE) loads based on detailed forecasting. Note: peak demand will exceed this value about 36 days per year, reinforcing the need for a healthy DRM.

N. The AEMO ISP's use of daily demand profiles to demonstrate grid performance is rejected for use in high reliability system design, which requires worst case conditions. The advent of EV recharging overnight will flatten future demand profiles (according to the 2022 ISP and supported by surveys which show most EV owners prefer/require overnight charging). Incentives (punishing tariffs) to recharge during daytime when solar power is often in surplus is highly problematic and unlikely to gain social licence. Worst case system design must use a flat peak demand. The 10% POE peak demand definition is further support for a conservative approach to worst case conditions.

O. Other costs applied to all models include transmission lines, low voltage distribution networks, grid stabilisation facilities, land acquisition for transmission lines (land costs are included in Gencost cost factors for generators), and an allowance for disposal, recycling and remediation.

P. While the accuracy of this whole-of-system cost estimation methodology is not precise, neither are all future model projections, which inevitably contain considerable uncertainty. However, we apply the same methodology to all seven case models, thus making relative accuracy among them better than absolute accuracy.

Appendix B Cost Model Notes

Baseline 20024 ISP Model Case

The Baseline ISP 2024 grid design contains severe deficiencies in both baseload power and energy storage capacity causing the DRM by 2030 to be minus 10% instead the desired plus 20% – a shortage of 30% in dispatchable power. For 2040 and 2050, the shortages exceed 60%.

Such a design could only be based on hopes that weather conditions will always enable 'some power' to be produced in 'some parts' of the grid to be delivered to the rest of the NEM by an extensive network of transmission lines. However, AEMO's historical power supply data[5] tells a different story of frequent periods, often on windless nights, when NEM available solar and wind power capacity factors fall close to zero. Some drought periods can last for more than three days and repeated episodes can often occur with only short intervals in between. Prolonged months-long spells can cause average renewable capacity factors well below expectations.

The AEMO 2024 ISP is a deeply flawed grid design which cannot deliver reliable power – blackouts are inevitable.

The cost of transmission network upgrades is based on the 2024 ISP plan to install 10,000 km of new transmission lines. Costs are estimated to be $1.3 to 2.0 million per km and subject to escalation. Significantly less transmission line costs are required for the four alternative cases.

The 2024 ISP "…assumes upgrades and other investments needed to enable distribution networks….will occur through other mechanisms…". This study makes an estimate for distribution network upgrade costs of about 5-10 thousand dollars per house based on expert opinion[6]. Much of this cost becomes unnecessary for the four alternative cases.

Stabilisation facilities such as synchronous condensers (costing $10-20 million each) will increasingly be required as baseload plants with rotating machinery are retired in favour of systems using electronic inverters. However, as with the transmission and distribution network costs, much of this is unnecessary for the four alternative cases.

Land acquisition costs for transmission lines are estimated from $200K-230K per km and are a subject of considerable debate in project approval hearings, where social licence is in short supply.

There is little information on projected costs for disposal, recycling and land remediation as a result of very substantial materials from expired wind turbines, solar panels and batteries. A nominal figure of $1-2 billion per year in future is used as large volumes of required replacements build up in the Baseline ISP case.

Baseline Plus Additional Gas Generation Case

The 2024 ISP phases out coal generation by 2037 and replaces CCGT (merit) gas plants with OCGT (flex) gas plants (designed to some day burn hydrogen, if or when available). To restore a plus 20% DRM, this Case adds much additional gas generation, starting in 2030, to almost quadruple the planned level by 2050. The daytime period is most critical since the minimal 2024 ISP storages will be depleted overnight and are primarily intended to handle short peak demands and transients.

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[5] Independent Engineers , Scientists & Professionals, Submission to AEMO CSIRO Draft 2024 ISP GenCost 9Feb2024, P18-20

[6] Electric Power Consulting Submission on the 2024 Draft AEMO Integrated System Plan

Maximum gas generation, hydro and biomass baseload provide a 20% reserve margin indefinitely during daytimes which rises well above 20% combined with storages at night. At night, gas generation would probably be lowered to reduce emissions but also at the cost of reducing the capacity factors of gas plants and their economic efficiency.

One implication of this case is the need to assure domestic gas supplies and deliver infrastructure are sufficient.

Costs for transmission lines and other elements remain as for the baseline case.

Table 1 provides a summary of key power system demand and DRM.

	2029-30		**2039-40**		**2049-50**	
	Night	**Day**	**Night**	**Day**	**Night**	**Day**
	GW	**GW**	**GW**	**GW**	**GW**	**GW**
Peak Demand	44.3	44.3	52.3	52.3	55.2	55.2
Baseload Power	53.2	53.2	62.5	62.5	66.5	66.5
Storage Power	5.9		10.8		16.2	
Dispatchable Reserve Margin %	33.3	20.0	40.1	19.5	49.7	20.5

Table 1 Baseline Plus Gas Generation Case

Baseline Plus Additional Storage and Wind & Solar Case

This Case leaves gas generation the same as in the Baseline Case and retires coal generation in the 2030s. A massive addition of extra utility battery storage of almost six times the level in the 2024 ISP by 2050, is required to achieve a DRM above 20% to protect against a worst case wind & solar drought on windless nights. And this also requires a corresponding massive increase in wind & solar to recharge them.

Even this large storage capacity would only cover a single night under worst case conditions.

The capital cost is estimated at $2.6-3.9 trillion. Since the marginal cost of adding batteries is $485 billion per day, a grid system with a seven day battery storage capacity would have a total capital cost of $5-7 trillion, even without adding more renewable recharge capability. The 10 year life of batteries also incurs massive ongoing replacement costs on the order of $3.5 trillion per decade.

Moreover, two further interrelated problems need addressing. The DRM during daytime – absent storage outputs – is disastrously below minus 50% so that there is no means to recharge the large battery capacity in the event of a wind & solar drought.

The reality is a reliance on a minimum level of at least 10% capacity factor for all wind and solar generation. This is not a real solution for DRM since wind & solar are not dispatchable.

In view of these estimates, this Case, widely touted as “firmed wind & solar with big batteries”, is simply neither technically viable nor economically affordable.

An 89% Gas Powered Grid Case

This Case follows on from the Baseline plus added gas Case. Capital cost is minimised by keeping the same gas generation, which together with hydro can indefinitely provide the plus 20% DRM both night and day. By halting further rollout of both wind & solar and battery storage after 2030, major capital cost savings are obtained as a trade-off against a lower reduction of operating emissions.

However, it should be noted that gas generation has about half the emissions of the present coal-based grid. The Case also avoids the substantial emissions involved in mining, processing and manufacturing of all of the materials required for wind turbines, solar panels and batteries and their frequent replacements. The amount of such materials has been estimated at about 700-900 times the materials needed for a typical baseload power plant. Therefore, the net increase in emissions of this Case may not be substantial.

Further, the very small environmental footprint of this alternative is negligible compared to wind and solar farms and is therefore another factor for consideration.

Another significant benefit is that gas and hydro facilities will run at higher capacity factors providing more attractive returns for investors, thus providing greater market stability and improving national productivity.

A detailed analysis is needed of the trade-off (Trade Off Analysis) in this Case between the lower capital costs and the postulated emissions reductions offset by the increased Renewable Materials Costs and other environmental benefits.

A 66/23% Coal/Gas Grid Case

This Case is a continuation of using coal generation and its expansion. Instead of retiring existing coal plants, they are replaced and expanded to double the present capacity by 2050. As for the previous Case, wind & solar and storage rollouts are halted after 2030.

While limited emission reductions are evident in this Case, potential exists for using advanced coal plant technology to improve efficiency. Carbon capture is not part of this model. However, benefits include the avoidance of renewable facility costs, a negligible environmental footprint and reduction of substantial emissions from mining, processing and manufacture of wind & solar.

As for the 89% Gas Powered grid Case, another significant benefit is that coal, gas and hydro facilities will run at higher capacity factors providing more attractive returns for investors, thus providing greater market stability and improving national productivity.

Again, a Trade-off Analysis is required for the Case.

A 40/49% Nuclear/Gas Grid Case

For this alternative, the GenCost 2024 cost assumption for large scale nuclear power plants is used. Ongoing product development of SMR systems is proceeding briskly at multiple companies including Rolls Royce (the manufacturer of the planned AUKUS submarine reactors). SMRs offer a vision of production line manufacturing efficiencies for standard products, which will be approved by multiple countries as are commercial jetliners, thus simplifying and shortening the approval process. It will be several years before SMR products are sufficiently mature to be able to assess their true cost factors. This has not prevented many countries from already placing orders for SMRs.

Nuclear fission power plant technologies have a 70 year history of increasing safety, maturity, minimal environmental impact and zero operating emissions, which provides an attractive option.

This Case posits a blend of gas (for fast reaction to load variations and grid transients) and nuclear power generation. The 2024 GenCost 2024 capital cost assumption for large scale nuclear plants can be favourably compared with other generation technologies when adjusted for estimated lifetimes as indicated in Table 2.

From this comparison, a nuclear power plant is effectively much more competitive than the GenCost 2024 results would indicate.

	Nuclear	Gas	Solar	Onshore Wind	Offshore Wind
Lifetime Years	80	30	20	20	20
GenCost 2024 Cost Assumption $B/GW	8.5	1.3	1.4	3.0	6.7
Lifetime Adjusted Nuclear Cost Assumption $B/GW	8.5	3.2	2.1	2.1	2.1

Table 2 Equivalent Nuclear Capital Cost Factor Adjusted for Lifetime

In this Case, rollout of wind & solar and storages are halted after 2030 because nuclear and gas baseload generation can run continuously, thus avoiding further capital costs. As its capital cost is much higher than gas plants, nuclear plant should be run continuously at high utilisation rates to achieve the lowest unit cost since the fuel cost per KWh is much cheaper than gas. The gas component provides an ability to quickly ramp up and down to compensate for variable load demands.

Since nuclear plant installation is unlikely to commence before mid-2030s, it is vital that new gas generation facilities be launched as soon as possible supported by expansion of domestic gas production infrastructure on the east coast. Gas is a critical component of all viable future electricity grid options. There should be no equivocation, unless it is preferred to maintain coal generation indefinitely. Gas will be the bridge to and ongoing support to reliable nuclear generation.

If it is desired to maintain some level of wind & solar in the grid, the substantial gas generation in this Case provides plenty of scope for backing up wind & solar. However, this will lower the capacity factors of the gas plants thus increasing their unit costs and the wind & solar will incur additional capital costs and increased emissions from mining, processing and manufacture of wind & solar.

Again, a Trade-off Analysis is needed for this Case.

A 58/31% Nuclear/Gas Grid Case

This Case increases nuclear power generation while reducing gas and maintaining hydro outputs. The increased capital cost relative to the previous case of 40% nuclear needs to be traded off against the potential for emissions reductions.