Submission to AEMO – CSIRO

Draft 2024 Integrated System Plan and Draft 2023-24 GenCost Report

Independent Engineers, Scientists and Professionals

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This assessment report concerns the draft 2024 Integrated System Plan (ISP) of the Australian Energy Market Operator (AEMO) and the draft 2023-24 GenCost Report of the CSIRO in response to calls for public review and comments.

This report was prepared and supported by independent engineers and scientists who have no monetary, employment, political or ideological links to this subject matter.

The views and conclusions presented are solely the opinions of the authors and supporters based on experience and professional qualifications.

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Conclusions and Recommendations

Submission to AEMO/CSIRO on the Draft 2024 ISP and GenCost

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This assessment finds the draft 2024 ISP for the future NEM fails to meet any of the national goals for reliability, low cost and zero emissions.

The ISP also does not meet consumer interests and is negligent regards detail, creates substantial risks to the environment, requires consumers to support the grid with solar PV and batteries, imposes intrusive controls on home generation, storage and usage of electricity, and poses significant risks to national security.

This submission finds that:

1. The ISP shows no evidence of the rigorous system engineering required for high reliability system development, taking into account worst-case conditions and reserve supply margins.
2. The draft 2024 ISP's NEM dispatchable reserve margin falls to minus 20% below maximum demand by 2030, whereas historically, a dispatchable reserve margin of at least +20% was in place to ensure reliability; this shortfall amounts to 18 GW.
3. The ISP's design severely lacks both energy storage and baseload back-up capacities, making it extremely unlikely to meet AEMO's required 99.998% reliability (10 minutes outage per year).
4. The ISP design relies on interconnectors to shift intermittent solar and wind power but fails when solar radiation across the entire network is zero for up to 16 hours every day and NEM-wide wind droughts lasting 3 days or more are evident in AEMO's own historical data. Interconnectors cannot shift non-existent power.
5. The ISP's wind and solar capabilities are inadequate to promptly recharge depleted energy storages in preparation of recurring needs in the near future.
6. Government policies restricting the NEM transition to a renewables-only approach are based on CSIRO's GenCost reports, which claim renewables are the cheapest form of electricity generation. The draft 2023-24 report's Disclaimer and stated limitations of its methodology argue strongly against this conclusion. The LCOE estimates for wind and solar power grossly underestimate the full costs of integration of renewables into a reliable grid design.
7. The ISP contains no data – whole-of-system whole-of-life costs, plus expected lifetimes of its components – to support its claim that the design is the lowest cost optimum development path.
8. A more realistic whole-of-system whole-of-life cost analysis with improved energy storages, baseload back up, more renewables for recharging, extra transmission lines, distribution system upgrades, stabilisation facilities (all with expected component lifetimes as appropriate) and massive land acquisition, will almost certainly show the ISP is far more costly than most other alternatives such as gas and SMRs.
9. The ISP fails to provide any accounting for NEM-wide CO_2 emissions regarding NetZero targets despite this being the fundamental justification for the NEM transition. A whole-of-system whole-of-life emissions analysis, including both domestic and offshore, must include mining, processing, manufacture, delivery, installation, maintenance, end-of-life decommissioning and disposal for all required components of the planned NEM. When these are taken into account, the proposed ISP NEM will not be net zero.

10. The draft 2024 ISP requires an estimated 1.7 million hectares of land for solar and wind farms and extra transmission lines. Such demands will have huge impacts on environmentally sensitive areas as well as on agricultural land. Many communities are already opposed to such impositions. The ISP's discussion of social licence issues to overcome these objections amount to little more than hope.
11. The draft 2024 ISP fails to address the technical feasibility and cost issues associated with disposal of components (panels, turbine blades, batteries, etc.) at end-of-life. There is little probability these issues will be resolved soon.
12. The draft 2024 ISP appears to believe that Demand Side Participation (DSP), which is already being implemented with VPPs (Virtual Power Plants), will be acceptable to the public through social licence means. But when the public recognises this as an Orwellian system of monitoring and controlling homes, disconnecting solar panels when the grid is in oversupply, disconnecting heating, air conditioner and EV chargers and drawing down batteries due to grid shortages, no amount of social licence talk will elicit acceptance.
13. The draft 2024 ISP fails to take into account several important implications for national security are severe. Firstly, a weakened economy from an unreliable and costly NEM will make adequate investments in military preparedness and economic resilience more difficult. Secondly, the ISP leads to almost complete dependence for this critical national infrastructure on China, the primary global supplier of products and materials for solar panels, batteries, turbines and EVs, which exposes Australia to interference and trade sanctions. Thirdly, there is a significant risk of cyber-attacks via embedded software in Chinese products disabling the NEM from the individual consumer to the entire network with flow-on effects to telecommunication services.

This submission concludes the draft 2024 ISP falls far short of being a viable plan and the draft 2023-24 GenCost report is substantially in error in that it fails to include all relevant integration costs into the renewable energy LCOE.

The transition of the NEM, which has been accelerating for several years, will lead to a collapse of system reliability should any more reliable baseload power generation be retired without prior implementation of the means to maintain proper positive dispatchable reserve margin under worst-case conditions. The ISP is no substitute for the previous properly designed and reliable NEM.

Recommendations

1. A thorough design review process in accordance with best-practice engineering of complex high reliability system development should be urgently implemented. This process should include qualified independent experts drawn from outside AEMO, government and energy industry to provide critical assessment, accountability and technical guidance on the design of the future NEM.
2. The CSIRO draft 2023-24 GenCost report, which underpins government policies and on which the ISP relies, should be substantially revised with the methodology updated with more realistic integration costs of renewable energy assets into the NEM. These integration costs should include all assets required to back up intermittent renewable energy generation to maintain acceptable stability and a dispatchable reserve margin under worst case conditions.

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1. Executive Summary

1.1 Introduction

Few would dispute the importance in the last century of plentiful low cost electricity as a primary driver of prosperity, high living standards and reductions in world poverty. Abundance of low cost energy from reliable electrical grids has not only had a profound effect on developed nations but remains a highly sought objective of today's developing nations.

In the past, Australia's economy benefitted from fossil fuels, which provided a resilient domestic energy supply, while also earning substantial export revenues. Reliable, low cost electricity is a key to economic productivity, which enriches the lives of all Australians. All people are intrinsically linked to the national electricity grid to support jobs and businesses, to heat/cool homes, for lighting and cooking, and sustainment to medically dependent persons and the elderly. A strong economy and reliable electricity grid is also of critical importance to national security.

Those many persons who have experienced lengthy electricity power outages of multiple days and weeks due to bushfires, flooding and weather events will not hesitate to nominate grid reliability as of paramount importance. Indeed, the draft 2024 ISP clearly states so.[1]

Therefore, all Australians are stakeholders in the future of the NEM system, not just environmental activists, the renewable energy industrial complex and those who have been appointed to or participated in the community outreach program of AEMO such as *"…planners and policy-makers, …asset owners and operators and market bodies"*.[2]

Since Australia already had a reliable, low cost electricity grid, it follows that the transition now underway from a coal-based generation system to primarily renewable sources is based entirely on stated government objectives to reduce carbon dioxide emissions as part of a world-wide Net Zero 2050 plan. Given the criticality of electrical energy to the well-being of all Australians, the assumptions and facts underlying this government policy, as reflected in the ISP, must be carefully assessed and critiqued for consequences.

The physical fact that CO_2 exists only as a gas in the atmosphere means that emissions diffuse rapidly across the entire globe making local effects from emission reductions irrelevant, despite the statements from some leaders and the media. The fact that developing nations already account for over half of global emissions (China and India leading the way), which will be over 70% by 2050, and that they are determinedly sourcing most of their energy needs from coal, means that any reductions – even 100% reductions – from Australia will make a negligible difference to global CO_2 levels.

Nevertheless, it is acknowledged that AEMO and CSIRO are obligated to respond to government policies with a plan aimed at providing 'reliable, low cost electricity and low emissions'. The draft 2024 ISP confidently advances its claim in this regard.[3]

[1] Pages 6, 22,36, 44, 67, 69
[2] Page 35 Section 3
[3] P6 Executive Summary

1.2 Overall Assessment

This submission evaluates the draft 2024 ISP for the NEM system, prioritising reliability, affordability and low emissions and developed in consultation with the energy industry.[4]

The draft 2024 ISP is an impressive array of complex text, charts, graphs and tables in 583 pages. Its technical complexity is beyond comprehension for most persons. Technical readers may be deterred by the sheer volume.

It is regrettable that the overall conclusion of this assessment by qualified professionals is that the draft 2024 ISP fails to demonstrate it can meet any of the national goals it sets forth, for reliability, least cost and low emissions. Moreover, the environmental impacts, the dependence on consumers to support the NEM instead of serving them as customers, and the risks to national security are dire.

An important conclusion is that a rigorous systems engineering design process based on worst-case conditions and a reserve margin to protect against facility outages is absent in the draft 2024 ISP in favour of narrative-based explanations.

For a plan that prioritises reliability, it contains no data on peak grid demand (found in AEMO's ESOO 2023 Report, which merits only a single reference in Appendix 4[5]). It talks about challenging worst-case conditions[6] but instead of rigorous analysis it presents illustrative examples with demand below worst-case[7], wind and solar outputs higher than worst-case and no reserve margin for facility outages. Reliable grid design cannot be based on average demand data[8] and neglect adequate reserve margins.

The draft 2024 ISP exaggerates dispatchable power, which is critical to ensure reliability. Charts showing generation capacities[9] provide misleading dispatchable power data by including the maximum power rating of 2-4 hour batteries – shallow, medium and consumer battery capacities[10] which are not usable for realistic back-up of the grid. Snowy 2.0 storage capacity is rated for 7 days operation when its lower reservoir is only 65% of the upper reservoir making full recharge dependent on natural rainfall and river flows[11].

The power generation and energy storage systems[12] defined in the draft 2024 ISP are easily tabulated with simple arithmetic into a top-level whole-of-system power budget. The results in Table 2-4 of this submission show there is insufficient dispatchable power to ensure the grid can continue to deliver reliable power to consumers throughout worst-case conditions when solar and wind power are in severe drought, such as overnight with zero solar across the entire NEM and wind droughts, which can last multiple days[13].

[4] P35 Section 3
[5] P43 Appendix 4.9
[6] P36 Section 3.2; P46 Section 4; P67 Section 6.5; P74 Section 8;
[7] P68 Figure 23; Appendix 4 p22 & 23 Figures 13 & 14
[8] P28 Figure 8 Average operational demand…; P62 Figure 20
[9] P10 Figure 2; P45 Figure 14
[10] P62 Figure 19
[11] Brooking and Bowden, An Overview of the Snowy 2.0 Pumped Hydro Energy Storage Scheme, 29 July 2022
[12] P10 Figure 2; P45 Figure 14; P62 Figure 19; Appendix 2 P8 Figure 1; P14 Table 1
[13] P68; Appendix 4 P2, 22, 26

The deficit in reliable dispatchable power is not small. Instead of a 20% dispatchable reserve margin in worst-case conditions, the top-level power budget demonstrates a 2030 margin of minus 20% (-9 GW) below worst-case demand, a deficit of 18 GW below the reserve margin which historically has kept the NEM reliable.

The ISP attempts to mitigate the very high cost of adequate energy storage facilities by a reliance on transmission line interconnectors to move 'anticipated' power surpluses from one region to another. However, when total system-wide power being generated as indicated by this top-level power budget is insufficient, then *interconnectors are of no value whatsoever*.

The draft 2024 ISP is therefore incapable of meeting the required 99.998% reliability specification[14].

Full costing of the whole NEM system is provided neither by the ISP nor by CSIRO's draft 2023-24 GenCost report. Despite the GenCost Report's clear disclaimer upfront and its limitations warning on page 54[15], it is widely quoted as the basis for the claim that renewables are the least cost means of electricity generation.

Not so, according to this assessment. Once whole-of-system, whole-of-life costs are properly tabulated, to include *proper capacities for energy storage and baseload power, system security upgrades, extra transmission lines, distribution network upgrades, extra variable renewable energy (VRE) for storages recharging, massive land acquisition and upgrades to the system operations management to orchestrate CER support to the grid*, the cost of a renewables-dominant grid design will be far higher than many alternatives.

A fundamental assumption in government policy without any sourcing, discussion or explanation is that renewables are zero emission technologies and are therefore the best (only) way to transition to a low emissions future. As with costs, it is unacceptable that the draft 2024 ISP provides no accounting of emissions on a whole-of-system, whole-of-life basis, nor any such comparison with alternative approaches.

Once full emissions (including offshore) associated with mining, processing, manufacturing, installation, operation and decommissioning are added, and consideration is given to the relatively short asset lifetimes, and inclusion of the full suite of energy storage, baseload backup support, system security and transmission assets required, a comparison of emissions with alternative grid design approaches is most unlikely to show renewables as the best choice. In fact, common sense alone makes it highly doubtful.

Environmental impacts of a renewables-dominant grid design are only now being understood by the wider population as massive amounts of land use required for solar and wind farms and transmission systems are revealed in public consultations. Social licence issues, which are

[14] P36 Table 2

[15] "Modelling studies such as AEMO's Integrated System Plan do not require or use LCOE Data. LCOE is a simple screening tool for quickly determining the relative competitiveness of electricity generation technologies. It is not a substitute for detailed project cash flow analysis or electricity system modelling which both provide more realistic representations of electricity generation project operational costs and performance."

discussed at length[16] in the ISP, entail substantial uncertainties provide little confidence beyond hope.

End-of-life disposal of massive quantities of solar panels containing toxic materials is a problem currently without a solution other than landfill burial. Likewise, wind turbine disposal results in very large amounts of non-recyclable fibreglass blades. Batteries have a short lifetime of up to 10 years and lack any practical and affordable options for recycling. The impact on natural wildlife populations is a long-standing issue.

The management of the complex systems required to accommodate intermittent and highly variable wind and solar power is a big challenge acknowledged by the ISP[17]. The reliance on goodwill (social licence) of a large fraction of the population for installation of solar panels and batteries at highly subsidised costs will predictably come to an end once subsidies disappear or at the end of life when additional investments for replacement are required.

Most discussion of social licence issues are relegated to Appendix 8. The previously used terminology – Demand Side Participation (DSP) – has disappeared in favour of "consumer mobilisation, adoption and orchestration"[18]. The plan for VPPs (virtual power plants) to coordinate CER in support of the grid, a complete inversion of the normal requirement for the grid to serve consumers, is not supported by consumer perceptions of value[19].

The need for centralised management controls for electricity supply and use in homes and businesses is a reflection of insufficient reserve margins resulting from poor system design.

Acute oversupply occurs during mid-day when solar power peaks cause potential voltage instabilities, which necessitates the shutdown of solar and wind farms and now millions of consumer installations, thus reducing the consumer's ability to offset their electricity bill. It will also be used to requisition energy from home batteries and EVs during grid shortage events and to turn off power to home air conditioners, water heaters, EV chargers, etc.[20]

There is a high risk that public perception will see this centralised command and control as Orwellian. In fact, the need for demand reduction and high costs will punish the poor more than the rich. It is a powerful self-indictment of the failure of the draft 2024 ISP to conduct proper planning and good engineering design. It is a first step towards rationing.

The implications for national security are also dire. The impact of an unreliable and costly NEM would weaken the economy making investment in military preparedness and economic resilience more difficult. The NEM transition is being implemented largely with products and materials produced by China, a country that has been identified as a geostrategic risk and which has enacted trade sanctions against Australia. Given the pervasive and growing threats from daily cyber-attacks on all governments, businesses and organisations, it is a serious omission that the draft 2024 ISP mentions cyber-attacks[21] only once in passing.

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[16] P76 Section 8.3
[17] P61 Section 6; P67 Section 6.5; P74 Section 8; P76 Section 8.2;
[18] Appendix 8 P16 Section 8.3
[19] Appendix 8 P 17 Section 8.3.1
[20] ESOO 2023 P161 A6.1 and P162 A6.2
[21] P74 Section 8

1.3 System Reliability

The draft 2024 ISP has shown progress over the previous ISP in providing more detail addressing reliability and system security matters. Unfortunately, a reliance on a narrative-based approach, absent of hard systems engineering analysis, projects little confidence that a rigorous and disciplined power systems design analysis has been undertaken.

Section 2 of this submission indicates that the 2024 draft ISP does not identify worst-case conditions nor include any reserve margin requirement to guard against facility outages, which are essential to high reliability system design.

Like all forecasts, significant uncertainties in future demand make the adoption of worst-case conditions and conservative reserve margins imperative. Worst-case demand forecasts need to account for consumer preference for EV charging overnight that is likely to somewhat level out the daily variations in demand, despite the draft 2024 ISP hopes that "*appropriate time-of-use electricity tariffs*" will shift consumers *"…away from convenience charging towards middle of the day charging*"[22]. This is prime example of a rigid mindset, punishing consumers into supporting the grid rather than the grid serving the consumer – when it is needed.

In fact, a simple whole-of-system, top-down grid power budget using only data provided by the draft 2024 ISP and demand data from AEMO's ESOO 2023 report, indicates that the ISP's design does not contain sufficient resources, in either generation or storage, to provide highly reliable electricity supply to the required 99.998%.

What is indisputable is that solar power, two thirds of all renewables in the draft 2024 ISP, is completely absent for two thirds of each 24 hour cycle across the whole NEM. Clouds also impede solar generation during daytime.

Wind power, the only renewable source during each non-daytime period, is subject to intermittency and high variability as detailed by AEMO statistical data records. It shows substantial and frequent droughts, lasting from hours to many days and even weeks in some regions. The ISP acknowledges these risks and does not include VRE as a dispatchable power source[23] but the NEM design does not reflect these facts.

Section 2 of this submission takes issue with Figures 2 and 14 of the ISP, which misleadingly shows the maximum dispatchable power in the NEM as a function of year without indicating that maximum power from energy storages is limited by capacities that in many cases enable maximum outputs for just a few hours. Figure 2.4 of this submission portrays dispatchable power more realistically and adds demand data for a comparison, which reveals real dispatchable power to be substantially less than demand. These figures also erroneously include DSP power, which is highly uncertain and unpredictable.

Dispatchable reserve margin, the percentage by which dispatchable power exceeds maximum demand is the key to guarantee a reliable electricity grid in the face of significant uncertainties. Historical AER data shows it to be about 20% in 2019 to cover unexpected outages in facilities and transmission networks.

[22] P27; Appendix 4.6 P10
[23] P10 Figure 2; P45 Figure 14

A top-level, whole-of-system power budget analysis reveals that the 2023 dispatchable reserve margin has fallen to a low level as a result of coal plant closures in the last five years. However, the power budget also indicates that it falls sharply into deep negative numbers in the next 26 years. Instead of plus 20%, it will be minus 20-30% by 2030. The implications for NEM reliability are very dire.

Figure 23[24] in the draft 2024 ISP attempts to illustrate an example of how the proposed grid design in 2040 would handle a severe renewables drought. However, investigation shows its wind and solar generation levels, while lower than average, are not worst-case conditions and demand levels are modelled with a deep 30% drop at night. In fact, the ISP admits that the example shows that insufficient generation prevents storages being adequately recharged and that the NEM would be vulnerable if major generator or transmission outages were to occur[25]. There is simply no reserve margin – this is not a proper system design.

1.4 System Costs and Affordability

The draft 2024 ISP is completely without any whole-of-system whole-of-life cost estimates and inherently relies on government policy for renewable energy targets, based on CSIRO's GenCost reports, which assert wind and solar to be the least cost method of generating electricity.

This is a major failing of the draft 2024 ISP, given that affordable cost is also government policy. There is no way the public can substantiate the claim[26] by the ISP that the *"…plan is the lowest-cost pathway…"* Neither does the plan contain any analysis of how consumer electricity rates will reflect the cost of transitioning the grid to renewables.

Numerous examples are provided, which illustrate the absence of cost data.

The CSIRO GenCost report displays a Disclaimer on its title page which refreshingly admits that its information may be "…incomplete or unable to be used in any specific situation." Yet this shortcoming is not taken into account by government policy and media reporting.

GenCost also details[27] the significant limitations of its Levelised Cost of Energy (LCOE) methodology despite a claim in its Executive Summary[28] that "*GenCost represents Australia's most comprehensive electricity generation cost projection*…" Limited time available prevents a more thorough assessment of the GenCost report.

Although AEMO's draft 2024 ISP disclaims the use of the LCOE data in GenCost, it is clear that government policy is predicated on GenCost[29].

[24] P68
[25] P68: Appendix 4.5 P24
[26] P3
[27] GenCost P54
[28] GenCost Pvii
[29] Joint Media Release: GenCost confirms renewables remain the cheapest form of energy, Hon Chris Bowen & Hon Ed Husic, 23 December 2023

The fact is that GenCost explicitly advises that its limitations[30] mean that LCOE *"…is not a substitute for…. electricity system modelling which…. provides more realistic representations of electricity generation… costs…"*

Section 7.2 of the draft 2024 ISP provides a glimpse of capital investment costs for generation, storage, firming and transmission, which are either $121 billion annualised or $138 billion upfront present value. These estimates appear contradictory and surely need further explanation.

Section 3.5 of this submission provides a simple capital cost projection for the (inadequate) energy storage facilities to 2050 in the draft 2024 ISP, using public data from government announcements of existing projects and reputable forecasts from the National Renewable Energy Laboratory in the United States. Significant forecast uncertainties result in a cost estimate of $204 billion to $357 billion for an energy storage system unable to supply adequate power for even a single overnight period. Expanding it to handle 7 days, as Snowy 2.0 is designed to do would cost several $trillion, an unaffordable cost. The only practical alternative is to increase baseload power capacity.

1.5 Total Emissions

The draft 2024 ISP provides emission reduction targets in percentage terms but not in projected absolute emissions in future years. It advises[31] that "Only scenarios that comply with Australian governments' emission reduction policies have been applied…"

This clearly indicates that the range of alternative ODP options analysed were constrained to renewables-only grid designs. Hence, any trade-offs with alternative concepts that may involve better cost effectiveness, more reliability and greater benefits to Australians were not considered.

When the whole-of-life cycle is considered for the facilities required by the NEM design in the draft 2024 ISP, it is obvious that emissions from mining, processing, manufacturing, delivery, site works, installation and end-of-life decommissioning and disposal have not been analysed and considered. However, intermittency and high variability of wind and solar generation also requires extensive support facilities to ensure reliability. This includes baseload gas and hydro, pumped hydro, batteries and stabilisation facilities, all of which are emissions intensive in their whole-of-life cycle and not required for a baseload electricity grid design.

This reality makes claims of net zero by 2050 for a renewables grid somewhat disingenuous. This subject requires a lot more study and transparency before the Australian public can be assured the draft 2024 ISP is the best overall approach to the future NEM. Only when AEMO has addressed the inadequacy of the draft 2024 ISP grid design can it make proper comparisons with alternative grid concepts.

Since the majority of Australia's planned energy infrastructure is being constructed with assets manufactured offshore, particularly in China where most energy supplies are from coal,

[30] GenCost P54
[31] P38

whole-of-life emissions must include offshore emissions. Climate effects from emissions are global, not local.

1.6 Environment Impacts

The environmental impacts on communities is only now becoming understood by the general public through consultative forums. Resistance is growing to these projects for wind and solar farms and transmission lines as the scale of massive land use, estimated at about 1.7 million hectares, is realised.

Social licence, which the draft 2024 ISP states includes community expectations, social and cultural values, environmental values and economics, needs to be earned according to the ISP[32]. It is obvious that the first three are intangibles, while economic considerations are of foremost importance to most people.

Relying on social licence to ensure implementation of a vast program of infrastructure is a very high risk due to the unpredictable nature of human responses.

When it comes to land use, community resistance can be inflamed by land clearing, displacement of agriculture and even visual impacts. However, it should be noted that addressing the inadequacy of generation in the draft 2024 ISP will undoubtedly involve significant expansions of wind and solar farms to recharge larger energy storages.

Compared with baseload power plants, renewable energy generation requires many hundreds of times the footprint.

Disposal issues have been neglected up to this point since most infrastructure has not yet reached its end-of-life. However, there are some very challenging issues regarding disposal of solar panels containing toxic chemicals, batteries with a range of toxic materials and large turbine blades, which contain large amounts of non-recyclable fibreglass. In most cases, methods of processing and recycling these materials have either not been technically or economically feasible.

Wildlife impacts have the highest visibility concerning the mortality of bird populations with wind turbines. However, habitat loss and displacement of animals are serious issues.

The draft 2024 ISP does not adequately address environmental issues.

1.7 Demand-Side Participation (DSP)

The formal definition of DSP, found in the Technical Standards for Distributed Energy Resources document approved in February 2021, reveals its purpose is to control consumer-owned PV sources, energy storage (including EVs) and loads such as air conditioners, hot water systems, pool pumps and EV chargers. This intrusive command and control enters homes when a consumer 'voluntarily' signs up for a VPP (virtual power plant) agreement.

The need for DSP and WDR (Wholesale Demand Response for businesses) to support the grid with 'consumer resources' is testimony to the lack of proper systems engineering design and

[32] P16, 33, 51, 76

planning in the draft 2024 ISP. Only the expectation that the future NEM will experience frequent power shortages would compel designers to consider DSP and WDR.

The fundamental purpose of utilities, such as electricity and water, is to serve consumer needs as and when they are needed. Simply put, DSP and WDR are an inversion of this purpose.

Social licence needs are canvassed in the draft 2024 ISP and as a sign of trepidation, the DSP name has been dropped in favour of 'consumer mobilization, adoption and orchestration'. The benefits are clearly aimed at the NEM, not the consumer, probably leading to a lack of consumer acceptance and trust.

The benefits to the grid are the ability to disconnect home solar PV from the grid when oversupply occurs (almost every mid-day) to prevent grid voltage instability, to draw down consumer batteries into the grid and to disconnect loads within the home, all done with software algorithms. Consumer benefits are limited to a possible sign-on bonus and possible reduced power tariffs. The potential loss of opportunity to sell surplus power to the grid at mid-day could reduce the ability to offset the consumer's power bill.

The reality is that the NEM design relies on consumer PV as 61% of all solar power and the largest single source (36%) of all power generation. It will also rely on consumer willingness to share their stored energy resources in times of grid shortages. The pitfalls are many; the risks are very high.

AEMO must overcome natural human tendencies to hoard in the face of uncertainty and stress. Appeals to higher community virtues to motivate people to a form of collectivisation could give way to fears of forced collectivisation. Such motivations can be fickle and disappear in a flash if people lose confidence in a system, which is designed from the outset to be inadequate to serve consumer needs.

Money in the form of punishment and rewards is more effective but the cost of subsidies is growing too large to be affordable in many jurisdictions. Removal or down scoping of them leads to dramatic loss of uptakes to home installations. The imposition of time-of-use tariffs to 'encourage' people to use energy only when it is more plentiful in daytime will work for a time but likely engender resentment and distrust and disproportionately impact the poor.

When EV owners come to grip with the fact their EV battery is being discharged at night when they expect it should be charging in readiness for use the next day, it is plausible that few will agree to this Orwellian control system intruding into their homes.

The consequences are that DSP uptake is uncertain and unpredictable, its benefits to the grid for balancing demand and supply are small and probably not worth the effort, the public will come to distrust a weak, unreliable system, it may cause disincentives for new industries to invest and create jobs in the future, and lower Australia's international reputation.

1.8 National Security

While it is beyond the responsibility of AEMO or this submission to make judgements on national security issues, it is nevertheless a citizen's duty to identify risks and bring them to the attention of governments.

There are serious potential risks to national security from an unreliable and costly electricity grid weakening the economy; an over dependence on products and materials sourced from China; and the integration of all homes and businesses into the power grid via internet connections with vulnerabilities to cyber-attack.

By themselves, these risks call for a complete rethink of the draft 2024 ISP.

Geostrategic trends in the past decade have prompted the 2023 Defence Strategic Review to identify threats to Australia's sovereignty and deficits in military preparedness.

Without economic strength, Australia will not have the resources to invest in military and economic means to independently survive. Few would dispute that an unreliable and costly electricity grid will weaken the entire economy. A grid built largely with products sourced from China greatly magnifies risks of economic coercion and trade sanctions.

Military operations at sea, in air and on the ground involve the absolute need for large amounts of energy, instantly available. Fossil fuels uniquely provide this capability and will never be replaced by electrification. Most of these oil-derived fuels are imported by sea. Better domestic reserves are needed but a strong military capability is also needed to deal with threats of interdiction.

It is indeed an oversight that the draft 2024 ISP mentions 'cyber' just once in passing. Given that ongoing cyber assaults are a daily occurrence, it is unfathomable that such an important area is completely overlooked.

There is considerable urgency for a review that properly investigates the impacts of the draft 2024 ISP on national security before the transition progresses further.

2. Reliability Assessments – The Top-Level System Design

The NEM reliability standard is defined in the ISP[33] as 99.998%, a common standard for public utilities. It is a tough standard – it requires the sum of all outages in any year to be less than just 10.5 minutes of system-wide output. AEMO measures reliability, as described in the Electricity Statement of Opportunities (ESOO) report[34], in terms of outages called Unserved Energy (USE) as a percentage of annual output. The bar for USE is therefore just 0.002%.

The reliability standard applies to the operation of the electricity grid. It is not easy to determine except by monitoring actual system performance over time. For detailed system design purposes, sophisticated statistical models can be run but that requires many detailed parameters, which are often difficult to accurately define and have significant uncertainties.

Subsection 1 below describes basic systems engineering principles behind high reliability system design. It defines maximum grid demands and worst case generation conditions that are critical inputs to the grid design process.

Subsection 2 below addresses the issue of dispatchable reserve margin and how an analytical top-level whole-of-system power budgeting approach, commonly applied in the planning process, is used in this assessment to indicate the viability of the draft 2024 ISP grid design for meeting its stated reliability requirement. It also evaluates the results of an eight day test of the Optimal Development Path (ODP) provided by the draft 2024 ISP.

Subsection 3 below discusses the feasibility of achieving high reliability through either increased energy storage or expanded baseload power generation.

2.1 Grid Design Principles for High Reliability

To achieve high reliability, a key system design principle is critical:

> A high-reliability system design must be based on worst-case conditions and then incorporate a margin of safety on top to guard against possible degradation of system capabilities.

Lives depend on getting engineering designs for high reliability right, whether it is a jetliner, a bridge, a building or a hospital. There are massive consequences for reliability failure.

The draft 2024 ISP dismisses worst case conditions as a rarity[35]. *In the field of complex system design, a common saying reminds engineers of their responsibility to design for worst case – even if they are considered rare: typically phrased as "Unlikely events happen all the time*".

In complex systems such as power grids, proper system design for reliability needs to take into account facility shutdowns for repairs and scheduled maintenance as part of normal operations. While this may appear to be just common sense, this principle appears absent in the draft 2024 ISP. Although the ISP expresses the importance of adequate reserve margins[36],

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[33] P36 Table 2

[34] ESOO 2023 p15

[35] P68 Historical weather patterns suggest that longer 'dark and still' periods of up to 3 days covering a wide geographical area are rare, with low risk of a NEM-wide event.

[36] P36 Table 2,P37, P62, P65, P66

the NEM design data in the ISP leads to large negative dispatchable reserve margins by 2030 thus providing evidence that this system design principle has not been implemented.

2.1.1 Worst Case Demand

Variations in consumer demands are addressed by the draft 2024 ISP[37] but there is considerable uncertainty as evidenced in the discussion in Appendix 4. In particular, EV charging is a significant and rapidly changing field. Observations such as "*Charging behaviour is not anticipated to be uniform*" and "*Smarter charging patterns are expected to become more widespread*" are based more on hope than knowledge[38].

The suggestion that shifting consumers *"…away from convenience charging towards middle of the day charging...*" through use of *"…appropriate time-of-use electricity tariffs...*" is more evidence of a mindset that poor grid design justifies forcing support from consumers rather than it being a service to consumers.

Realistically, large-scale EV uptake will place a very high demand on overnight charging (and require substantial upgrades to local distribution networks) due to many EV owners needing to use their cars during daytime. Daytime recharging will necessitate employers and public carparks installing recharge facilities on a vast scale and not address weekend charging.

In the face of considerable uncertainty of future patterns of grid demand, it is only prudent that the worst-case design assumption for the grid be based on constant maximum grid demand throughout the day and night. The only downside to this assumption would be additional reserve margin at certain times of the day. *Failure to anticipate an adequate maximum demand design assumption inevitably means shortages, reduced margins and negative implications for reliability.*

Grid designs based on average demands will not provide system reliability under worst case conditions. It is odd that the draft 2024 ISP does not provide forecast NEM demand data. A single reference to it is buried in a footnote in Appendix 4. In fact it is available in the ESOO 2023 report and on AEMO's Forecast portal.

The maximum demand data from ESOO 2023 are shown in Table 2-1. The data is cast in terms of Probability of Exceedance (POE) statistics – 50% means that the value will be exceeded half of the time. Clearly 10% data is preferable as worst case but still implies that it will be exceeded on 36 days per year. The analysis in this submission uses the 10% POE data, and provides further justification for the assumption of constant worst case demand throughout a 24 hour cycle.

State:	**NEM**	**Max Demand GW (sent out)**			
	Summer			**Winter**	
FY	**10% POE**	**50% POE**	**Cal Year**	**10% POE**	**50% POE**
23-24	39.1	36.4	**2024**	34.0	33.1
29-30	44.3	41.4	**2030**	39.6	38.5
39-40	52.3	49.0	**2040**	47.3	46.0
49-50	55.2	51.9	**2050**	50.5	49.2
ESOO 2023 Appendix A Tables 19-23 pp 130, 139, 148, 155					

Table 2-1 ESOO 2023 Max Demand Forecast Data

[37] P27 Future Daily Demand Profiles, P28 Figure 8, P63 Figure 20, Appendix 4 P9, 10
[38] Appendix 4.2 P10

Summer demand is significantly higher than winter, hence must be used as worst case. *Note that all forecasts contain significant uncertainties; a conservative approach is therefore justified.*

2.1.2 Worst Case Power Generation

Worst-case generation conditions will inevitably occur in non-daytime periods when solar power is completely absent every day and simultaneously across the entire NEM, and wind droughts occur. Solar is about two thirds of all VRE in the draft 2024 ISP. Add in a few unplanned facility outages affecting baseload power and the conditions for blackouts are highly likely, as already occurred in June 2022 and December 2023.

The challenge of ensuring there will be sufficient power through a non-daytime period that can last as long as 16 hours is substantial and made more difficult when historical data published by AEMO shows wind droughts lasting 3 or more days[39] [40]. The draft 2024 ISP also warns that "…future weather may not replicate the past ...so there may be longer and more widespread variable renewable energy (VRE) droughts"[41].

Cloudy conditions can also impact solar power production. Large scale weather systems can often affect much of the entire NEM, reducing solar outputs by about 25% in light clouds, 50% in medium clouds and up to 75% in heavy storm clouds. Figure 2.1 illustrates these conditions with satellite data from the BOM.

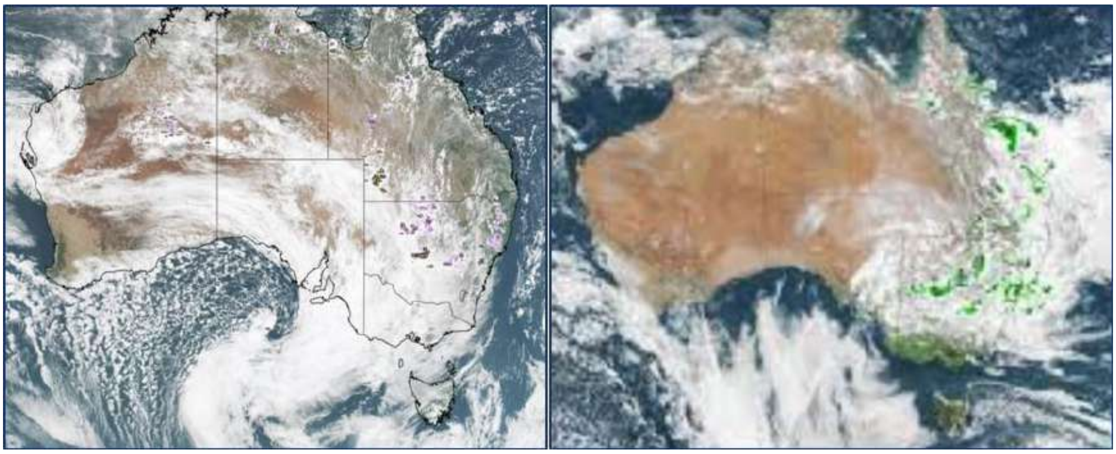

Figure 2.1 Cloudy Conditions Affecting Almost All of the NEM

Wind droughts across the entire NEM occur frequently. Figure 2.2 contains two weather charts from the BOM illustrating how large areas can be affected by high pressure zones with low gradients, which can linger for days. Winds also vary during the 24 hour cycle. Uneven thermal heating of the surface often produces local winds, which decline at nightfall.

Figure 2.3 shows the situation in June 2020, when capacity factor (percentage of maximum capacity) of total wind power fell seven times below 5% and less than 15% for most of a 9 day period.

[39] P21 Appendix 4.5 Resilience During VRE Droughts "Long, dark and still conditions typically last for hours or a whole day….on rare occasions they persist for multiple days.

[40] P23 Appendix 4.5 NEM Resilience through prolonged VRE droughts "The timing severity and duration of prolonged dark and still conditions over a wide area are difficult to forecast..."

[41] P68

Media reports and scientific papers indicate that wind power in the UK (and Europe) in 2021 was consistently below expectations for periods of several months. A paper[42] published by the Royal Meteorological Society by a group from the UK Met Office states "Wind drought events of up to two consecutive weeks have been observed, but the model indicates a 1-in-40 chance of three or more continuous weeks of wind drought each winter, with the single most prolonged simulated event lasting 5 weeks."

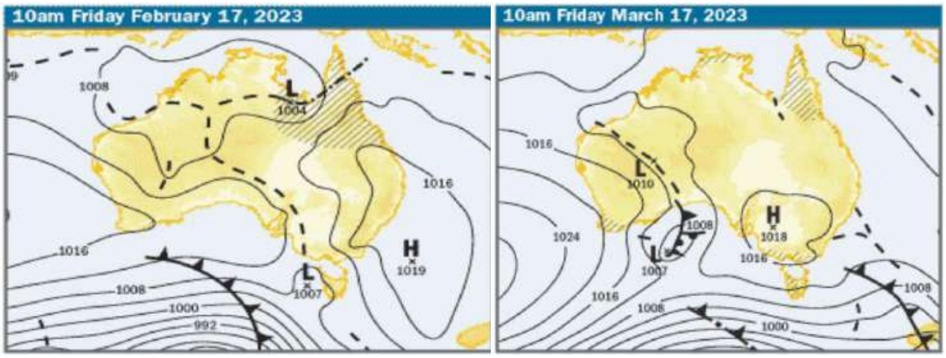

Figure 2.2 BOM Weather Charts Showing Large Zones of Low Pressure Gradients

Figure 2.3 Total Wind Capacity Factor for June 2020

Table 2-2 provides statistical data on wind power droughts across almost eleven years showing both the number of events by duration and by capacity factor based on AEMO records. Maximum durations exceed 30 hours most years. This reality is backed up by Appendix 4 which states "*Long, dark and still conditions typically can last for hours or a whole day but are most problematic for system operability on the rare occasions they persist for multiple days.*"[43]

Appendix 4 also states "*The timing, severity and duration of prolonged dark and still weather conditions over a wide area are difficult to forecast and indications are these events are very rare.*"[44]

Wind droughts are certainly not rare events and it is indisputable that solar power is zero every day across the entire NEM for periods of up to 16 hours.

The above data leads to the definition of worst-case generation conditions for use in grid system design. Clearly, the availability of VRE is highly variable and intermittent. It cannot be relied upon to provide significant power during dark and still, worst-case conditions,

[42] Gillian Kay et al, Variability in North Sea wind energy and the potential for prolonged winter wind drought, Atmospheric Science Letters/Volume 24, Issue 6, 8 March 2023
[43] Appendix 4 P21
[44] Appendix 4 P23

sometimes lasting many days. It is therefore not included in the definition of dispatchable power capacity used in the draft 2024 ISP, as evidenced by the data in Figures 2 and 14.[45]

	Number of Events of Wind Drought								
	Length of Period when CF <= 10%					Annual	Capacity Factors		
Year	4-6 hrs	6-10 hrs	10-14 hrs	14-18 hrs	18+ hrs	Max hrs	0-6%	6-8%	8-10%
7mo/2022	9	14	4	1	2	20 h	3	18	19
2021	17	30	10	5	0	16 h	9	36	52
2020	22	27	14	4	4	34 h	21	21	53
2019	16	33	9	6	4	42 h	18	34	57
2018	28	34	9	5	5	57 h	17	51	54
2017	15	34	15	5	17	71 h	28	41	57
2016	24	17	18	2	6	62 h	17	35	64
2015	10	24	17	11	16	39 h	25	46	45
2014	29	29	22	2	13	46 h	19	51	77
2013	30	30	15	6	9	54 h	26	48	64
2012	20	33	12	6	19	66 h	36	46	59

Table 2-2 AEMO Wind Drought Data for Eleven Years[46]

The need for sufficient VRE power subsequent to each wind drought to rapidly and fully recharge storages is also an inherent requirement to restore readiness for the next drought condition, which can quickly follow as demonstrated in Figure 2.3 above.

2.1.3 Dispatchable Power from Energy Storages

Dispatchable power is provided by baseload power generators such as coal, gas and hydro as well as energy storages as shown in Figures 2 and 14 of the draft 2024 ISP. Unlike continuous baseload power, the rated maximum power output from storages is available for a period time constrained by the size of the energy storage capacity (power x time measured in units of watt hours: kWh, MWh and GWh). However, these figures are based on the sum of all rated maximum power outputs, providing a misleading impression of high dispatchable power.

Figure 19[47] in the draft 2024 ISP defines both the rated maximum power output capacity and energy storage capacity. Storages are categorized in the ISP as coordinated consumer (CER) storage, passive CER storage, and utility storages of shallow (<4 hrs), medium (4-12 hrs) and deep (> 12 hrs). Snowy 2.0 and Borumba are pumped hydro storages.

Regarding coordinated CER storages, the draft 2024 ISP states[48]: "*While the combined installed capacity of these batteries is large, they can only dispatch electricity for about two hours at full discharge, so their energy storage capacity is relatively small, and deeper, utility-scale storage is needed... and ..Coordinated CER storage is managed as part of a virtual power plant (VPP) while Passive CER storage is not*."

The ISP identifies shallow storages being primarily used for system security purposes[49]. This functions to smooth sharp fluctuations over minutes and a few hours that can occur due to variability of RE and grid demands, not for system backup when sufficient VRE power is not available.

[45] P10 and P45
[46] Brooking and Bowden, Firming Wind Farms with Batteries, December 2022
[47] P62
[48] P62 Section 6.1
[49] P62

Energy storages can, of course, output power over longer periods at lower levels. Table 2-3 shows the breakdown of ISP-defined storages from Figure 19, their maximum rated power and duration, as well as their power output over longer durations.

2023-24	Storage Capacity	Rated Max Power	Dur. At Max Power	Dur. hrs 8	Dur. hrs 16	Dur. hrs 24	Dur. hrs 48	Dur. hrs 168
Energy Storage	**GWh**	**GW**	**Hours**	**GW**	**GW**	**GW**	**GW**	**GW**
Snowy 2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Borumba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shallow	4.2	2.6	1.6	0.5	0.3	0.2	0.1	0.0
Medium	7.7	0.8	9.6	0.8	0.5	0.3	0.2	0.0
Deep	6.3	0.2	31.5	0.2	0.2	0.2	0.1	0.0
Coordinated CER	0.9	0.5	1.8	0.1	0.1	0.0	0.0	0.0
Total		**4.1**		**1.6**	**1.0**	**0.7**	**0.4**	**0.1**

2029-30	Storage Capacity	Rated Max Power	Dur. At Max Power	Dur. hrs 8	Dur. hrs 16	Dur. hrs 24	Dur. hrs 48	Dur. hrs 168
Energy Storage	**GWh**	**GW**	**Hours**	**GW**	**GW**	**GW**	**GW**	**GW**
Snowy 2.0	376.2	2.2	171.0	2.2	2.2	2.2	2.2	2.2
Borumba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shallow	12.2	6.7	1.8	1.5	0.8	0.5	0.3	0.07
Medium	26.7	3.6	7.4	3.3	1.7	1.1	0.6	0.16
Deep	6.3	0.2	31.5	0.2	0.2	0.2	0.1	0.04
Coordinated CER	7.5	3.7	2.0	0.9	0.5	0.3	0.2	0.04
Total		**16.4**		**8.2**	**5.3**	**4.3**	**3.3**	**2.5**

2039-40	Storage Capacity	Rated Max Power	Dur. At Max Power	Dur. hrs 8	Dur. hrs 16	Dur. hrs 24	Dur. hrs 48	Dur. hrs 168
Energy Storage	**GWh**	**GW**	**Hours**	**GW**	**GW**	**GW**	**GW**	**GW**
Snowy 2.0	376.2	2.2	171.0	2.2	2.2	2.2	2.2	2.2
Borumba	48.0	2.0	24.0	2.0	2.0	2.0	1.0	0.3
Shallow	17.9	9.6	1.9	2.2	1.1	0.7	0.4	0.11
Medium	28.4	3.8	7.5	3.6	1.8	1.2	0.6	0.17
Deep	42.1	1.1	38.3	1.1	1.1	1.1	0.9	0.25
Coordinated CER	56.0	18.1	3.1	7.0	3.5	2.3	1.2	0.33
Total		**36.8**		**18.1**	**11.7**	**9.6**	**6.2**	**3.3**

2049-50	Storage Capacity	Rated Max Power	Dur. At Max Power	Dur. hrs 8	Dur. hrs 16	Dur. hrs 24	Dur. hrs 48	Dur. hrs 168
Energy Storage	**GWh**	**GW**	**Hours**	**GW**	**GW**	**GW**	**GW**	**GW**
Snowy 2.0	376.2	2.2	171.0	2.2	2.2	2.2	2.2	2.2
Borumba	48.0	2.0	24.0	2.0	2.0	2.0	1.0	0.3
Shallow	7.6	3.9	1.9	1.0	0.5	0.3	0.2	0.05
Medium	27.5	3.5	7.9	3.4	1.7	1.1	0.6	0.16
Deep	51.4	1.3	39.5	1.3	1.3	1.3	1.1	0.31
Coordinated CER	143.7	37.3	3.9	18.0	9.0	6.0	3.0	0.86
Total		**50.2**		**27.9**	**16.7**	**13.0**	**8.0**	**3.9**

Table 2-3 Breakdown of Energy Storage Capacity and Power vs Duration

For a typical outage, which occurs overnight lasting about 16 hours, the total deliverable power level is less than a third of the maximum rating. Snowy 2.0 will provide power at its maximum rated level of 2.2 GW for 7 days (168 hours) starting with a full reservoir; Borumba pumped hydro will provide its maximum 2.0 GW over just one day. Shallow storage is included here although the ISP states that its use will most likely be for short term smoothing of grid wind and solar; its contribution (if available) to overnight power is quite small.

Figure 2.4 below is a chart of dispatchable power as a function of duration limited by available energy storages as indicated in Table 2-3. It also plots the maximum rated dispatchable power from Figure 2 of the ISP, maximum 10% POE demand from Table 2-1 and the grid worst-case design requirement with an additional 20% dispatchable reserve margin.

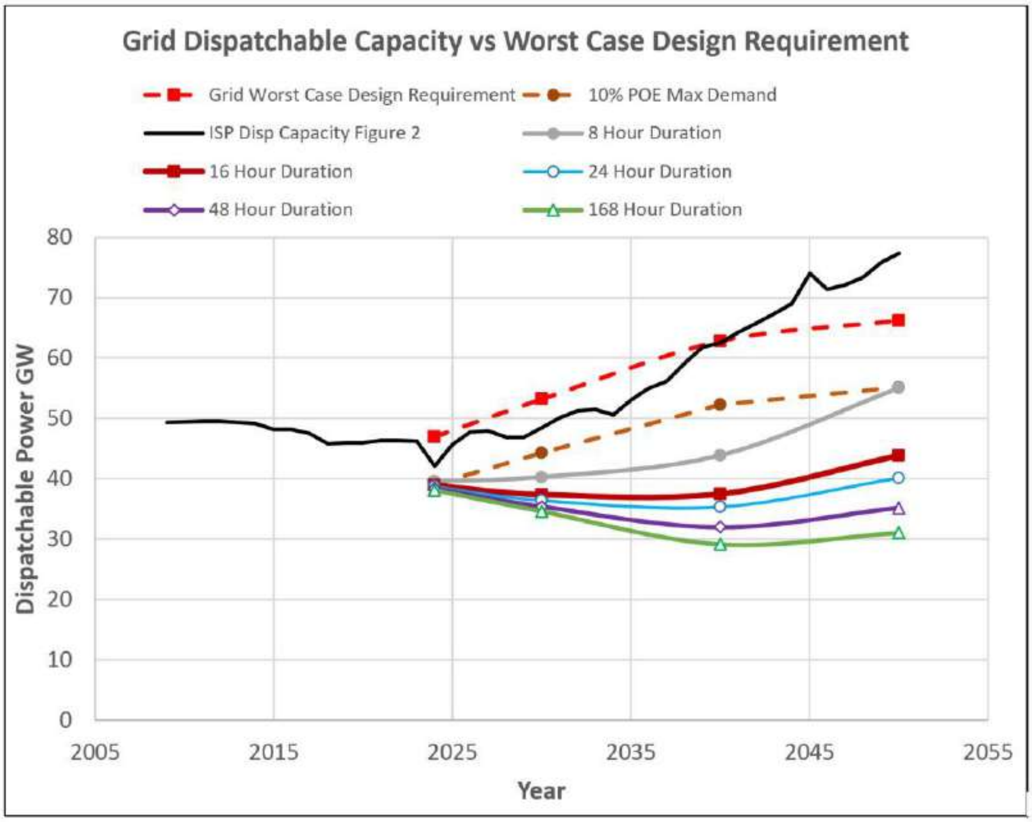

Figure 2.4 Dispatchable Power Capacity vs Grid Design as a Function of Duration

The following observations are made:

- Current dispatchable power is barely able to cover the 2024 10% POE maximum demand overnight, it does not provide significant reserve margin and explains why, as a result of coal plant shutdowns, instances of apprehended grid shortages and blackouts are already occurring.
- By 2030, dispatchable power will be far less than what a reliable grid design (with a 20% reserve margin) requires – by about 15 GW.
- By 2040 and 2050, the shortage of dispatchable power approaches 30 GW.
- These results, based entirely on the grid design data contained within the draft 2024 ISP, makes it clear that reliable consumer power will be substantially dependent on wind power during non-daytime periods when solar is zero.
- The total capacities of planned energy storages are completely inadequate to handle periods when wind power is in drought in non-daytime periods.

- Future shortages in dispatchable power are not small; they are massive. The 99.998% reliability standard of the NEM cannot possibly be met with this design. Either baseload power capacity or expensive energy storages will have to be substantially increased.
- The use of transmission interconnectors will not ameliorate this problem. These figures for dispatchable power are for the whole NEM system. There is simply insufficient dispatchable power in total.
- Multiple day wind droughts are not so rare that they can be ignored – under such worst-case conditions the NEM grid will suffer extensive blackouts that will be viewed as grid collapse.
- The fundamental flaw in the draft 2024 ISP is the assumption that sufficient variable and intermittent VRE will always be available, if only transmission interconnectors are built to move it to wherever shortages exist. This assumption is not adequately addressed by any kind of analysis. A grid design dependent on VRE is not viable.

2.2 The Essential Dispatchable Reserve Margin

The major problem with the draft 2024 ISP is that the proposed NEM grid design is unable to provide reliable power during droughts when wind and solar power are at a very low level. Section 6.5[50] attempts to allay concerns by describing VRE droughts[51] as *"…common, local events that typically last a few hours or a day or two…"* It states that "*Peak demand is forecast to be met within the reliability standard throughout the entire forecast period, through combinations of renewable generation and storage, backed up at times by gas when required.*"[52]

As seen in Sub-section 2.1 of this submission, NEM-wide shortages of VRE are not just local nor rare. Interconnectors are unable to redistribute power surpluses that do not exist.

A grid system design criteria that is widely used for both top-level system planning and assessment of grid status is the "dispatchable reserve margin". This is defined as *the percentage by which total dispatchable (on-demand) power capacity exceeds maximum demand*. This measure is easy to compute and is a good predicator of system reliability, which is required to be 99.998% (10 minutes per year).

This reserve margin in the grid design is intended to enable normal system operation to continue when facility outages occur for maintenance and repairs. In the past, the reserve margin has exceeded 20% and ensured the reliability standard was met. Figure 2.5 contains data from the Australian Energy Regulator (AER) website showing total power capacity exceeding maximum demand by 40% in 2019-20 of which 20% is dispatchable and 20% is non-dispatchable VRE.

What percentage should the dispatchable reserve margin be to guarantee the reliability requirement of the NEM in the future? The draft 2024 ISP provides no answer. It talks about reserves, about dispatchable capacity but not about the dispatchable reserve margin.

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[50] P67
[51] P68
[52] P67

Yet, when LOR (Lack of Reserve) events occur, AEMO is quick to alert the public to insufficient reserves and the need for people to reduce demands.

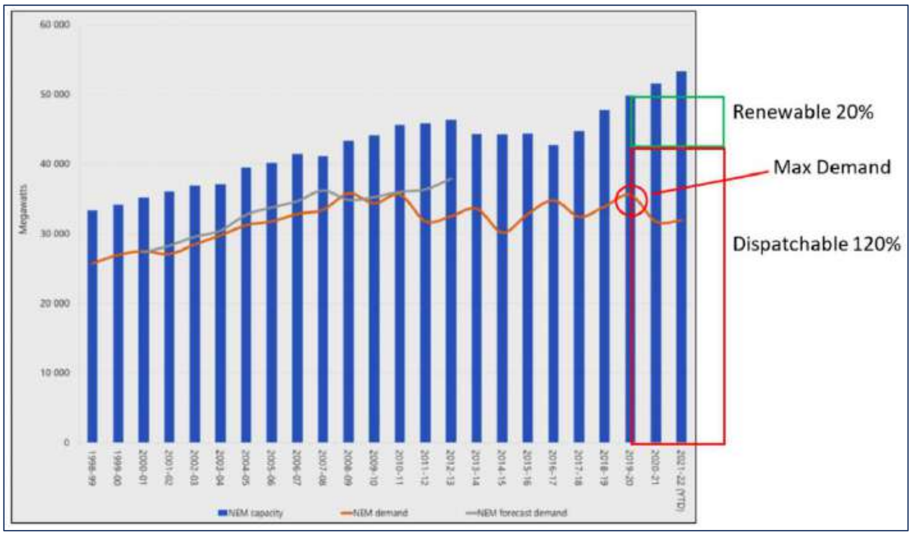

Figure 2.5 AER Historical Data Shows NEM Dispatchable Capability Exceeding Maximum Demand

2.2.1 The Top Level Whole-of-System Power Budget

An analytical top-level whole-of-system power budgeting approach, which is widely applied in planning processes, is used in this assessment to indicate the viability of the draft 2024 ISP grid design for meeting its stated reliability requirement. The draft 2024 ISP does not present any such information nor any data on dispatchable reserve margin in forecast years.

While the accuracy of a top level whole-of-system power budget is not as high as a simulation containing detailed models of all facilities, it is entirely adequate to provide an indication of overall system performance. Moreover, it inherently assumes the existence of 100% interconnection of the grid.

All of the sources of power generation and storage for this analysis are taken from the draft 2024 ISP.[53] The maximum NEM demand data are from AEMO's ESOO 2023 report.

As a starting point for analysis, the power budget breaks the 24 hour cycle into two periods: an eight hour daytime period when solar is available and 16 hours of non-daytime when solar is completely absent. All storages start at 100% capacity and all generation facilities operate at maximum output.

Table 2-4 provides the worst-case top-level whole-of-system power budget when maximum demand is continuous and both solar and wind are zero. This defines the baseline worst-case condition, where dispatchable power is the only available source.

The results of this worst-case analysis are:

- The current 2024 dispatchable reserve margin (3.5%) is very low – consistent with recent grid LOR experience with high demand and some facility outages.

[53] P10 Figure 2; Appendix 2.2.2 P13 Table 1; P45 Figure 14; P62 Figure 19

- The projections for 2030, 2040 and 2050 demonstrate a sharp deterioration to substantial (minus 20-30%) negative margins – the dispatchable margins will no longer guarantee reliable power delivery under these conditions. Since no facility outages have been factored in, the dispatchable reserve margin should be plus 20%.
- Baseload power eliminates coal by 2040 and falls by about 15 GW (38%) by 2040 while the design requirement for demand increases by 34%. The 2040 38% increase in gas is insufficient to compensate for the loss of coal and the increase in demand.
- A large increase in baseload power and/or storage is required to restore realistic levels of dispatchable reserve margins (17.4 GW/2030; 27.7 GW/2040 and 25.1 GW/2050).

AEMO NEM Grid Design per 2024 DRAFT ISP														
Worst Case & 20% Reserve Margin			**2023-24**			**2029-30**			**2039-40**			**2049-50**		
24 hr Top-level Whole-of-System Power Budget				Night	Daytime		Night	Daytime		Night	Daytime		Night	Daytime
Duration hours				16	8		16	8		16	8		16	8
NEM Power Demand				GW	GW		GW	GW		GW	GW		GW	GW
10% POE Max Demand (ESOO 2023)				39.1	39.1		44.3	44.3		52.3	52.3		55.2	55.2
Dispatchable Reserve Margin	20%			7.8	7.8		8.9	8.9		10.5	10.5		11.0	11.0
Total Design Requirement				**47.0**	**47.0**		**53.2**	**53.2**		**62.8**	**62.8**		**66.2**	**66.2**
Power Sources (Draft 2024 ISP)	**Capacity Factors**		**Capacity**			**Capacity**			**Capacity**			**Capacity**		
Baseload Power	Night	Daytime	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW
Coal - Black & Brown	100%	100%	21.2	21.2	21.2	11.5	11.5	11.5	0	0.0	0.0	0.0	0.0	0.0
Gas - Mid Merit & Flex	100%	100%	11.5	11.5	11.5	11.8	11.8	11.8	16.3	16.3	16.3	17.3	17.3	17.3
Hydro	100%	100%	6.8	6.8	6.8	7.2	7.2	7.2	7.1	7.1	7.1	7.1	7.1	7.1
Total Baseload Dispatchable			**39.5**	**39.5**	**39.5**	**30.5**	**30.5**	**30.5**	**23.4**	**23.4**	**23.4**	**24.4**	**24.4**	**24.4**
Energy Storage Draft 2024 ISP)			**GWh**			**GWh**			**GWh**			**GWh**		
Snowy 2.0 + Borumba			0.0			376.2			424.2			424.2		
Deep			6.3			6.3			42.1			51.4		
Medium, Shallow, Coord CER			12.8			46.4			102.3			178.8		
Total Storage Capacity			**19.1**			**428.9**			**568.6**			**654.4**		
Storage Max Power Capacity			**GW max**	**GW**	**GW**	**GW max**	**GW**	**GW**	**GW max**	**GW**	**GW**	**GW max**	**GW**	**GW**
Snowy 2.0 + Borumba			0.0	0.0	0.0	2.2	2.2	2.2	4.2	4.2	4.2	4.2	4.2	4.2
Deep			0.2	0.2	0.2	0.2	0.2	0.2	1.1	1.1	1.1	1.3	1.3	1.3
Medium, Shallow, Coord CER			3.9	0.8	0.0	14.0	2.9	0.0	31.5	6.4	0.0	44.7	11.2	0.0
Total Max Storage Power			**4.1**			**16.4**			**36.8**			**50.2**		
Avail. Storage Power Dispatchable				**1.0**	**0.2**		**5.3**	**2.4**		**11.7**	**5.3**		**16.7**	**5.5**
Total Dispatchable Power				**40.5**	**39.7**		**35.8**	**32.9**		**35.1**	**28.7**		**41.1**	**29.9**
Surplus/Deficit(-) wrt 10% POE Demand				**1.4**	**0.6**		**-8.5**	**-11.4**		**-17.2**	**-23.6**		**-14.1**	**-25.3**
Dispatchable Reserve Margin				3.5%	1.4%		-19.2%	-25.7%		-32.9%	-45.1%		-25.6%	-45.8%
VRE Renewables (Draft 2024 ISP)														
Wind: Onshore	0%	0%	10.4	0.0	0.0	39.6	0.0	0.0	52	0.0	0.0	61.4	0.0	0.0
Wind - Offshore	0%	0%	0.0	0.0	0.0	0.0	0.0	0.0	9.0	0.0	0.0	9.0	0.0	0.0
Solar Utility	0%	0%	8.4	0.0	0.0	17.4	0.0	0.0	29.4	0.0	0.0	55.5	0.0	0.0
Solar Distributed VPP	0%	0%	21.3	0.0	0.0	36.1	0.0	0.0	60.2	0.0	0.0	85.7	0.0	0.0
Non-dispatchable VRE			**40.1**	**0.0**	**0.0**	**93.1**	**0.0**	**0.0**	**150.6**	**0.0**	**0.0**	**211.6**	**0.0**	**0.0**
Total Dispatchable + VRE Power				**40.5**	**39.7**		**35.8**	**32.9**		**35.1**	**28.7**		**41.1**	**29.9**
Surplus/Deficit(-) wrt 10% POE Demand				**1.4**	**0.6**		**-8.5**	**-11.4**		**-17.2**	**-23.6**		**-14.1**	**-25.3**
	Efficiency				**GW**			**GW**			**GW**			**GW**
Req'd Daytime Recharge Power	**80%**				**2.5**			**13.3**			**29.2**			**41.7**
Avail. NEM Daytime Recharge					**0.4**			**-13.8**			**-28.9**			**-30.8**
Recharge Power Surplus/Deficit(-)					**-2.1**			**-27.1**			**-58.1**			**-72.5**

Table 2-4 Worst-Case Top Level Whole-of-System Power Budget

This analysis strongly indicates that the draft 2024 ISP design of the future NEM is not based on an adequate dispatchable reserve margin to provide reliability of supply.

Given the ISP's reliance on intermittent and highly variable wind and solar energy for reliability, AEMO fails to provide a rigorous and detailed analysis of historical weather patterns and VRE generation modelling data to demonstrate with statistical certainty that the proposed NEM design will meet its 99.998% reliability requirement. The draft 2024 ISP does not provide or reference any such engineering work.

The available data to date for wind power droughts, as provided in Section 2.1 of this submission, indicates that frequent system-wide wind droughts, when combined with the complete absence of solar power every night across the entire NEM, will make the delivery of reliable power entirely dependent on baseload generation and energy storages, which Table 2-4 shows are inadequate.

The use of uncertain forecasts of variation in demand optimistically reducing each night despite the probable advent of widespread EV overnight charging, provides no confidence. Adding more wind and solar power resources, as flagged in the ESOO 2023 will not rectify a dispatchability problem, which is caused by their intermittency and variability.

Objections will be raised that this top-level whole-of-system analysis is too conservative by assuming max power demand is continuous and wind power is zero through an entire 16 hour non-daytime period. The only downside of this design assumption is a system which has higher dispatchable reserve margin and excellent reliability. The risk of discounting these assumptions is a non-robust system, which leads to blackouts and power rationing.

In addition, under worst case conditions, the negative daytime dispatchable reserve margin indicates power availability of surplus power to recharge storages is non-existent.

2.2.2 Multiple Day VRE Droughts

The above analysis looks at a single 24 hour cycle and finds it wanting to a large degree. What is the outlook for multiple day variable renewable energy (VRE) droughts as acknowledged[54] by the draft 2024 ISP?

Figure 23, “Operability through eight-day VRE drought, NEM except QLD[55]” in the ISP, shows the results of a 2040 test of the ODP through drought conditions across the southern areas of the NEM (excluding QLD) for eight days. The results, it is claimed, show that: ”…*the power system remains reliable and secure*…”. But it also acknowledges that: “…*reliability risks would be elevated, particularly if major generator or transmission outages occur*”.

The draft 2024 ISP suggests this test is more conclusive than it actually is: “AEMO therefore tested the ODP to see whether it could meet the reliability standard through drought conditions across the southern regions of the NEM for eight days – a period at least twice as long as and more severe than any since 2010, and possibly since 1980.”

It sounds impressive to a casual reader but consider these facts:

1. The test included imports of limited power from QLD yet represents a partial system.
2. The test included maximum power from all dispatchable resources.
3. The extreme drought conditions were for 6 days not 8.
4. Wind capacity factor was 10% in daytime; 13% overnight.
5. Solar capacity factor was 13-15%.

[54] P68
[55] P68

6. Non-daytime grid load in early evening when storages are not charging was about 32 GW decreasing by 31% after midnight to about 22 GW; the ESOO 10% POE demand is 38 GW.

These are not worst-case conditions.

A test of this nature is not a rigorous engineering analysis; it is simply a demonstration of one set of conditions, which in this case are not representative of the design requirements and which, for a reliable system would include a 20% reserve margin to handle facility outages. As noted above, "*…reliability risks would be elevated, particularly if major generator or transmission outages occur...*"

Appendix 4.5 of the draft 2024 ISP states the test indicates that *"…insufficient spare generation to fully charge all shallow and medium storages…"* and "*…reserve levels are getting dangerously low*…"

Narrative-based explanations and illustrative examples are not sufficient to demonstrate that critical 99.998% reliability will be achieved under worst-case conditions.

2.3 Reliance on Wind and Solar Power

The previous sub-sections indicate the draft 2024 ISP is highly deficient in dispatchable generation resources needed to make the NEM design reliable. There are only two alternatives for rectifying the design:

1. Add energy storages
2. Add baseload generators

2.3.1 Additional Energy Storage

Key issues regarding adding more storage capacity are as follows:

- What is the maximum required duration of "Deep" storages when wind and solar droughts can last for days?
- Does the grid have sufficient VRE resources to reliably recharge the storages quickly and efficiently before another drought can occur?
- What impact will there be on whole-of-system costs and consumer electricity rates?

There are no easy answers to these questions and it is not the objective for this review to conduct a complete redesign for the NEM.

It is sufficient to observe that traditional baseload power plants would usually keep on-hand supplies of coal exceeding 30 days. Uncertainties in weather impacts in VRE have been addressed by various analysts advocating for storage capacities of multiple weeks. Snowy 2.0 has a capacity of nominally 1 week but this was probably a function of terrain geography rather than system engineering analysis of grid requirements.

To put it in perspective, a one-week storage capacity to meet a requirement for a reliable grid design in 2039-40 amounts to 6619 GWh, about eleven times the size of the storage capacity of the draft 2024 ISP design (580 GWh).

The draft 2024 ISP has limited resources for recharging even the current inadequate energy storage systems. The expansion of energy storage capacity would require very large increases in VRE installations on a scale that would exceed the power capacity of the planned VRE. The impact on total system costs would be substantial and probably unaffordable. Section 3 of this submission provides more insight.

2.3.2 Additional Baseload Generation

A more feasible alternative than adding energy storages is to consider additional baseload generation facilities. The draft 2024 ISP shows gas peaking plants (flex gas) as providing increasing power capacity to the NEM by 2040. The grid design requirement (including a 20% dispatchable reserve margin) for 2040 is 62.4 GW while the draft 2024 ISP baseload generation capacity is 23.4 GW. Hence an extra 39 GW of baseload power would be needed and would reduce the very expensive battery-based energy storage option.

Gas is the most likely candidate for additional baseload power; the costs are well known, the technology is reliable, Australia has very large reserves of gas and the environmental impact is very small except for the issue of emissions (which are lower than coal plants). The result would be virtually a complete duplication of the grid to achieve reliability in the face of intermittent and variable renewables (VRE). The total grid cost would probably be significantly lower than VRE plus energy storages.

Nuclear energy, particularly small modular reactors (SMR), have been discussed in public forums and through the media lately. However, at this stage in their development, uncertainties remain, especially regarding costs. In the next 5 years, more information will become available. SMRs are expected to be commercially available by the early 2030s.

But one issue is critical to note. It is illogical to operate SMRs as a back-up to solar and wind power when they offer:

- No CO_2 emissions
- Reliable 24/7 operation at high utilization rates
- Simpler grid management
- A very small environmental footprint
- Little need for additional transmission lines
- No impact on system security
- No need for back up or energy storage

To do so would condemn SMRs to operate at low utilization rates, just as has occurred with remaining coal power plants as a result of subsidies, taxes, preferences and regulations designed to drive them out of business. SMRs must be embraced as primary power generation facilities to enable them to be efficient, productive and cost effective.

Nuclear power ticks many boxes when government objectives are considered. Operations produce no emissions. They will be available from nations that do not pose any geostrategic risks. Waste products are very small in volume and can be safely stored in the same Australian facilities which will be built for the AUKUS submarine project.

The promise of SMRs is the development of standard modular designs, which have regulatory approval processes much like commercial aviation. They will also be manufactured on mass production lines that will reduce costs and enhance delivery schedules. They are an option with a proven underlying technology base.

Nuclear power, as declared at the recent COP28 conference, is a viable future alternative to the installation of VRE networks.

3 System Costs – Whole-of-System Whole-of-Life

Costings in the draft 2024 ISP largely missing and yet have major implications. This section discusses some of the more important costing issues related to the ISP.

3.1 Missing Whole-of-System Cost Data

Two major failings of the ISP are the absence of whole-of-system whole-of life cost data and the impact of government policy to constrain the ISP solution towards a renewables-only approach. It is the widely-quoted but contentious CSIRO GenCost report, which appears to drive energy policies.

The draft 2024 ISP makes a brief statement of system costs in terms of annualized capital investment and equivalent upfront capital investment, which needs a full explanation and breakdown to have any credibility. Most of the cost discussions are focused in Appendix 6 regarding net market benefits of various transmission line projects

Transmission line infrastructure is a major focus in the ISP, firstly to connect remote Renewable Energy Zones (REZ) to the grid and also an apparent belief that interconnectors are a substitute for expensive energy storage systems.

The GenCost report, cited by the draft 2024 ISP only once,[56] is said to be the source of capital and operating costs rather than Levelised Cost of Electricity (LCOE) information. However, GenCost uses this data in computing LCOE costs to compare various generation technologies and conclude that wind and solar generation are the cheapest forms of energy generation. This conclusion underpins government policy, the direction of the ISP and media reporting.

3.2 The Lowest Cost of the Future NEM

CEO's preface[57] to the draft 2024 ISP starts with a claim that "*The plan outlines the lowest-cost pathway of essential generation, storage and transmission infrastructure*..." It also cites the National Electricity Law which requires AEMO to plan the power system to be *"...secure, reliable and cost-effective.*" However, it fails to point out that AEMO's scope is limited by government policy that restricts it to renewable energy architectures.

In the executive Summary[58], the ISP states unequivocally that "*The optimal development path is the lowest cost, resilient, pragmatic path to the NEM's energy future*." It continues with the claim[59] that *"...renewable energy connected with transmission, firmed with storage and backed up by gas-powered generation is the lowest cost way to supply electricity to homes and businesses*..." In fact, it also points to the fact that this represents no change from the 2022 ISP[60] and reiterates this approach throughout the ISP.

Despite the AEMO regarding the ISP as the lowest cost approach to the future NEM, it fails to qualify it as pertaining to renewables-only designs and does to provide any comprehensive whole-of-system cost information. It is not sensible, nor acceptable to the Australian population, that such a momentous transition of the most vital infrastructure underpinning the national economy can be justified without providing a comprehensive accounting for

[56] P44
[57] P3
[58] P8
[59] P9
[60] P18

system-level costs…. and a genuine comparison with a wider set of alternative system design approaches.

The draft 2024 ISP fails to provide cost data for the following key elements of its design consisting of the following:

1. Existing and future gas generators
2. Hydro-electric dams
3. Pumped hydro energy storages
4. Utility battery storages – shallow, medium and deep
5. CER storages
6. Offshore wind generators
7. Onshore wind generators
8. Utility solar farm generators
9. CER roof top solar generators
10. Transmission line upgrades
11. Distribution network upgrades[61]
12. System security upgrades – stabilization
13. System management upgrades for consumer mobilization, adoption and orchestration[62]
14. Land acquisitions for installation of wind and solar generation assets
15. Land acquisition costs for transmission line installations
16. Removal and disposal costs for solar panels, wind turbines and batteries

The ISP appears to treat most elements as being the responsibility of investors and consumers, hence beyond the need to provide cost data. For example, consumer-owned assets, which are described as essential to the future NEM, are paid for by a combination of individual consumers and substantial subsidies paid by taxpayers, who are in fact the consumers. It does not matter who pays – all costs are a burden on the national economy.

Another example, distribution network upgrades (connecting transmission lines to residences and businesses through low voltage networks) is identified in the ISP Section 5, “Actionable and other network investments”. Yet no distribution projects whatsoever are described in the extensive list of transmission upgrades. Instead, the draft 2024 ISP reveals in ISP Section 9 that further analysis will be required[63] before the final 2024 ISP is released.

Early knowledge of the costs of such critical elements is vital to decision-making. Given the extensive size of distribution networks, the likely cost of upgrades could be very substantial.

The reluctance to provide whole-of-system costs for the transition of the NEM leads to a number of legitimate questions:

1. How do the total costs of the NEM transition impact consumer rates for electricity?
2. Will government (taxpayers) continue to subsidise the entire energy system?
3. Why are consumers (and taxpayers) expected to pay for the cost of home/business battery energy storages which are twice the cost per unit storage capacity than utility scale batteries?

[61] P51 Section 5 “New transmission and modernized distribution networks are needed...”
[62] P17 Appendix A8.3
[63] P81 Section 9.3

4. Who will pay for the costs for removal and disposal of considerable volumes of solar panels, wind turbines and batteries all of which have short lifetimes compared to conventional baseload generators?

3.3 Levelised Costs in CSIRO's GenCost Report

The front page disclaimer of the GenCost report and its stated limitations of LCOE should not be ignored[64] nor its stated limitations of LCOE[65].

The Disclaimer plainly disavows any responsibility for the data and conclusions of the GenCost report, yet its conclusions appear to be the bedrock upon which government policy and AEMO's ISP are based. It also disclaims any liability for its use which is a standard legal precaution, but the first three sentences are worth close examination:

"*CSIRO advises that the information contained in this publication comprises general statements based on scientific research.*

The reader is advised and needs to be aware that such information may be incomplete or unable to be used in any specific situation.

No reliance or actions must therefore be made on that information without seeking prior expert professional, scientific and technical advice."

Despite these warnings the CSIRO's GenCost reports are taken as accurate and suitable foundations for government policies, which constrain the entire energy transition to be renewables-based. Not even the GenCost Executive summary, which claims the report is comprehensive (but fails to mention its accuracy), should override the Disclaimer.

Indeed, the second sentence is indeed truthful as this submission concludes. The information is certainly incomplete in that LCOE modelling is unable to account for all of the grid system costs, when multiple technologies and support systems are required.

The reality is that the annual GenCost reports are widely cited in media and government circles as being the gold standard of evidence that renewables are the cheapest technology for generating electricity. This is the public perception. Disclaimers are never quoted.

The limitations of LCOE modelling are buried deep inside the GenCost report. Section 5.1[66] notes the following limitations:

- LCOE is a simple comparison metric
- Modelling studies such as AEMO's ISP do not require or use LCOE
- It is not a substitute for detailed project cash flow analysis or electricity system modeling.
- LCOE does not take account of the additional costs associated with each technology and in particular the significant integration costs of variable renewable(s)
- A new method has been developed in 2020-21 to address integration costs for renewables.

[64] GenCost Title page
[65] GenCost P54
[66] P54 GenCost report, Section 5.1 Purpose and Limitations of LCOE

The GenCost Executive Summary[67] claims that "*GenCost represents Australia's most comprehensive electricity generation cost projection report*." It fails to mention the limitations (above) or the Disclaimer. It may indeed be the most comprehensive of what is available but it falls far short of what is needed to determine the total costs of the entire NEM grid transition and neither does the draft 2024 ISP provide such data. The Australian public deserves better.

The AEMO's draft 2024 ISP confirms it does not require or use LCOE[68], but this is disingenuous in that government policy and the ISP are entirely predicated on the GenCost report's conclusion, based on LCOE, that renewable wind and solar are the cheapest technologies for electricity generation.[69]

Given the explicit limitations stated by GenCost[70] that LCOE *"…is not a substitute for… electricity system modelling which… provides more realistic representations of electricity generation project operational costs and performance*", the foundational basis for government policy mandating the use of primarily renewable wind and solar power generation for the NEM is highly contestable.

The fact is that intermittent and variable wind and solar generation requires:

- the building of a complete parallel power system of expensive energy storages and baseload generators to provide the same power to meet grid demands for extended periods when dark and still conditions reduce VRE power to near zero;
- the building of extra VRE resources to recharge energy storages;
- building of extensive additional transmission lines and interconnectors;
- the upgrading of local distribution networks;
- the acquisition of massive land areas to accommodate wind and solar farms, and
- the installation of stabilization and control facilities to maintain grid synchronicity.

None of these additional facilities are required for a grid system built with reliable 24/7 baseload generation assets. Common sense alone dictates that rigorous and transparent economic trade-off studies be undertaken of the proposed approach and comparisons be made with alternative system designs to validate any decisions. The pace and criticality of the NEM transition demands urgent action to review and rethink the design approach to the NEM before money is wasted on unaffordable and non-viable solutions.

The draft 2024 ISP states that only capital and operating costs from the GenCost report are used[71]. Where is the ISP cost modelling? Where are the results? Despite the above-mentioned failings of the GenCost, the draft ISP accepts its capital and operating costs without modelling and comparison of any real alternatives.

3.4 Top-level Costs of the Draft 2024 ISP

ISP Part B, Sections 4, 5, 6 and 7 define the optimal development path (ODP) for reliability and affordability.

[67] Pvii GenCost
[68] P44 Part B An optimal development path for reliability and affordability
[69] Joint Media Release: GenCost confirms renewables remain the cheapest form of energy, Hon Chris Bowen & Hon Ed Husic,23 December 2023
[70] P54 GenCost
[71] P44

The scale of renewables (Section 4), network investments (Section 5) and storages and services (Section 6) are defined for the ODP, but do not include any explanation or breakdown of costs.

ISP Section 7,[72] describes "…how and why AEMO has determined the ODP…" ISP Appendix 6 is referenced but supplies only the results of cost benefit studies relating to transmission infrastructure.

ISP Section 7.1 refers to "…$121 billion in essential capital investment…"[73] It further defines this on the next page: "The annualised capital cost of all generation, storage, firming and transmission infrastructure in the ODP has a present value of $121 billion in the Step Change scenario to 2050." On the other hand, the same paragraph also states: "The equivalent upfront capital cost for generation, storage, firming and transmission infrastructure in the ODP has a present value of $138 billion in the *Step Change* scenario to 2050."

However, footnote 30 states "This value ($121 billion) does not include the cost of commissioned, committed or anticipated projects". What does it include?

The first figure is annualised capital costs; the second figure is equivalent upfront capital costs, but which is correct? Both figures cannot be correct. Note that an annual cost of $121 billion for the next 26 years is a total of $3.146 trillion. The government of Australia has never admitted to this figure. This statement certainly needs explanation.

If the true cost of the NEM transition is $3.146 trillion for the lowest cost for a renewables-based option, its practicality, productivity and cost effectiveness need careful scrutiny and a wide system-level comparison with all alternatives, unencumbered by CSIRO's GenCost claims.

Section 7.3 describes alternative approaches to the ODP.[74] "*Cost assessments have explored alternatives such as the undergrounding of transmission, replacing coal with gas and carbon capture and storage, and the impacts of large hydro developments. Alternative paths result in either more reliability risks or greater costs or both, and many substantially so*." This narrative is does not indicate any variation from a renewables-based grid design approach.

3.5 Capital Cost of Energy Storages to 2050

The issue of "firming" renewables appears 24 times in the draft 2024 ISP. What is poorly explained is that there are two needs: short term smoothing (minutes or a few hours) of fluctuations of highly variable wind and solar generation, and backing up renewables in bulk when there is insufficient wind and solar to meet consumer demands. Section 2.3 of this submission critiques the inadequacy in the scale of energy storages in the ISP for back up.

Energy storages are widely acknowledged to be very expensive, a point that is underplayed by the ISP. The draft 2024 ISP defines two long-life projects for pumped hydro, Snowy 2.0 and Borumba. Snowy Hydro reported on 31 August 2023 that the capital cost for Snowy 2.0 is now estimated at $12 billion[75]. As of 12 December 2023 the Queensland government estimates

[72] P69
[73] P70
[74] P71
[75] https://www.snowyhydro.com.au/news/securing-the-future-of-critical-energy-transformation-resets/

the full cost of the Borumba Dam project at $14.2 billion[76]. Further escalation in costs of these major projects, as experience shows, is likely.

Utility storages for deep, medium and shallow are assumed to be mostly batteries. CER energy storage is also based on battery technology.

Forecasts for battery costs contain significant uncertainties. Two credible sources are the National Renewable Energy Laboratory (NREL) and the Pacific Northwest National Laboratory. (PNNL), both under the US Department of Energy. NREL's 2023 paper[77] on battery costs provides a 2022 nominal unit cost of US$490/KWh ($731/KWh). PNNL's August 2022 paper[78] provides a 2021 "installed" lithium battery cost estimated at US$408/KWh ($608/KWh) based on a 4 hour 100 MW battery for grid storage.

NREL provides a set of normalization curves (high, mid and low range) for future cost estimates as shown in Figure 3.1.

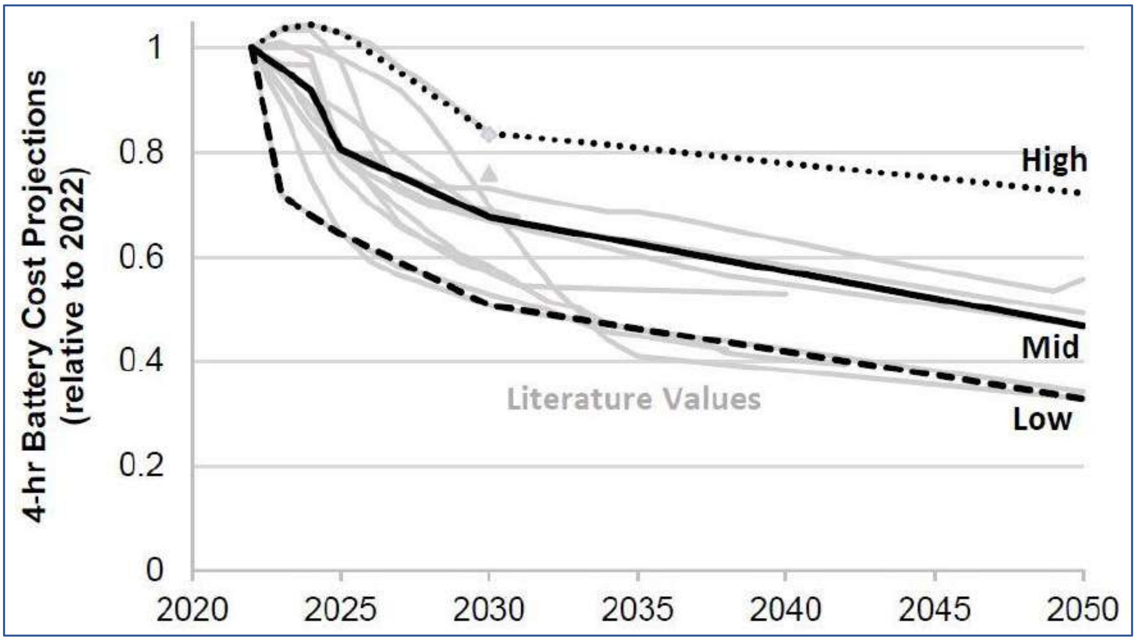

Figure 3.1 NREL Normalisation Factors for Future 4-hr Lithium Battery Costs

In December 2022, ARENA announced approval[79] for eight big battery projects in Australia. The average unit cost for these projects was $643/KWh, probably costed for 2023. The Hornsdale big battery installation in SA, Phases 1 and 2, cost $161 million for 194 MWh for a unit cost of $830/KWh[80].

CER battery unit costs are estimated from data on multiple websites offering Tesla batteries with installation. A cost of AUD1150/KWh is an average installed cost for 2023.

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76 https://www.epw.qld.gov.au/about/initiatives/borumba-dam-pumped-hydro

77 Cole, Wesley and Akash Karmakar. 2023. Cost Projections for Utility-Scale Battery Storage: 2023 Update. Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A40-85332. https://www.nrel.gov/docs/fy23osti/85332.pdf.

78 Viswanathan et al. Technical Report, Publication No. PNNL-33283 August 2022

79 ARENA Announcement December 2022, https://arena.gov.au/blog/arena-backs-eight-big-batteries-to-bolster-grid/

80 Brooking and Bowden, An Overview of the Costs of Firming Wind Farms with Batteries, Revision 1.0, 10 March 2021

These costs are summarised in Table 3-1 scaled to $ billion/GWh.

Table 3-2 is a simplified top-level model for the Draft 20204 battery storage capacities for three decades ending 2030, 2040 and 2050 using the mid-level normalizing curve shown in Figure 2.1. For this estimate, the reference 2023 ARENA unit cost for utility batteries and the reference 2024 Tesla unit cost for CER batteries are used.

Source	**NREL**	**PNNL**	**ARENA**	**Hornsdale**	**Tesla**
Ref Year	2022	2021	2023	2021-23	2024
Cost	0.731	0.608	0.643	0.830	1.150

Table 3-1 Battery Cost Estimates in Australian Dollars $billion/GWh

The unit costs for each decade are for years 2027, 2035 and 2045 respectively using the NREL normalizing chart. The draft 2024 ISP data defines the battery capacities at the end of each decade and thus the increment over the previous decade. The assumed 10 year lifetime of the batteries is reflected in each decade for additional replacement of the previous decade's batteries.

	Mid Range NREL Normalisation					
Utility Batteries cost $/GWh	0.514		0.405		0.334	
Decade	2020 to 2030		2030 to 2040		2040 to 2050	
Deep +	Energy	Capital	Energy	Capital	Energy	Capital
Medium +	Capacity	Costs	Capacity	Costs	Capacity	Costs
Shallow	GWh	$ billion	GWh	$ billion	GWh	$ billion
Total Installed (ISP)	45.2		88.4		86.5	
Decadal Install	45.2	23.3	43.2	17.5	-1.9	-0.6
Decadal Replace			45.2	18.3	88.4	29.6
Cum Total to 2050						**88.0**
CER Batteries cost $/GWh		0.920		0.725		0.598
Decade	2020 to 2030		2030 to 2040		2040 to 2050	
Coordinated +	Energy	Capital	Energy	Capital	Energy	Capital
Passive	Capacity	Costs	Capacity	Costs	Capacity	Costs
	GWh	$ billion	GWh	$ billion	GWh	$ billion
Total Installed (ISP)	13.7		68.9		157.1	
Decadal Install	13.7	12.6	55.2	40.0	88.2	52.7
Decadal Replace			13.7	9.9	68.9	41.2
Cum Total to 2050						**156.5**
Total Cost of draft 2024 ISP battery storages			$ Billion			**244.5**

Table 3-2 Mid-range Estimate of Capital Costs for Batteries Draft 2024 ISP

The mid-range cost estimate for the battery capacities in the draft 2024 ISP is $245 billion to 2050. The NREL normalizing data in Figure 3.1 shows a very large spread from 2030 onwards, which reflects considerable forecasting uncertainties. Similar tables using the high and low NREL normalizing curves provide a cost estimate range between $177 billion and $330 billion.

Add to those figures about $27 billion for pumped hydro (Snowy 2.0 and Borumba) for a total energy storage cost of $204 – 357 billion. This cost estimate for just one element of the ISP, which has been assessed in Section 2.2 of this submission to be substantially undersized, is considerably in excess of the "$138 billion for all capital cost for generation, storage, firming and transmission infrastructure."

Section 2.3 of this submission estimates that an energy storage design eleven times greater would be required to match the 7 day storage capacity of Snowy 2.0 and require a massive increase in VRE to provide adequate recharging capability.

Such a design would lead to an unaffordable energy storage system costing several $trillion, most of which would require replacement every ten years (Australia's GDP is about $2 billion). With much of it requiring replacement every ten years that's an average annual outlay of hundreds of millions of dollars, which would be borne by consumers and taxpayers.

Another observation that deserves an answer: From Table 3-1, CER consumer batteries are almost twice the unit cost of utility scale batteries yet in the draft 2024 ISP they make up 65% of battery capacity by 2050. How does this result in the draft 2024 ISP ODP (optimum development path) being the lowest cost?

4 Emissions – Whole-of-System Whole-of-Life

The draft 2024 ISP does not provide any data on emissions, perhaps because AEMO incorrectly believes that they are zero. Subsection 1 describes how this belief actually hinders it ability to conduct trade-off studies with alternative NEM configurations which better balance cost reliability and emissions. Subsection 2 sets out why wind and solar emissions are in fact not zero. As a result, the ISP does not provide any comparative data on emissions, as noted in subsection 3. The final subsection 4 explains why offshore emissions from other countries which manufacture the bulk of all equipment being installed in Australia's future NEM must be counted.

4.1 Missing Emissions Data

The draft 2024 ISP states percentage emission reduction targets for various states[81]. It also points to a recent addition of an emissions reduction element to the National Electricity Objective (NEO) in the electricity law requiring AEMO to plan the power system in a way that helps governments achieve targets that reduce greenhouse gas emissions – as well as being secure, reliable and cost effective[82].

At the national level, the targets[83] are "net zero emissions by 2050" and "43% reduction by 2030 supported by an 82% renewable energy target" defined under a number of government policies.

As a result, the draft 2024 ISP advises that "Only scenarios that comply with Australian governments' emissions reduction policies have been applied…"[84] clearly indicating that the ISP planning work is entirely focused on a renewables-only approach.

From numerous public statements, government policies are based on the CSIRO GenCost report which describes renewables as the cheapest form of electricity generation and an assumption that renewables are emission free. This is despite the fact that GenCost describes its LCOE methodology as "…a simple comparison metric……not a substitute for detailed electricity system modelling…[85]"

Despite ISP claims to have conducted numerous scenario analyses to select the optimum development path, the work has been entirely constrained to renewables only and a strict adherence to net zero dogma. As Section 3 of this submission shows, the energy storage system costs are so large that common sense suggests a wider set of alternative concepts should be investigated.

The strict net zero emissions target prevents any real consideration of cost/reliability trade-offs with emissions to be considered. The very large variability of climate model predictions is evidence of considerable uncertainty[86] in the real impact of CO_2 in the atmosphere. Is a flexible low emission target achievable with a secure, reliable and cost effective NEM design?

The constraints government policies impose on AEMO prevent wider comparisons of alternative system concepts, which may better serve the Australian public.

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[81] P35
[82] P38
[83] P31
[84] P38
[85] P45 GenCost Report
[86] Koonin, Unsettled, What Climate Science Tells Us, What it Doesn't and Why It Matters, 2021

4.2 Emissions from Renewables

The foundational assumption that renewables are zero emission is flawed – it applies only to daily operations.

- The mining, processing, manufacturing, delivery, site works, installation, and end-of-life decommissioning and disposable operations all involve significant emissions.
- The amount of raw materials required to manufacture and build a renewables electricity grid is hundreds of times more than that required for an equivalent conventional baseload power grid.
- Intermittent and variable wind and solar require extensive support facilities to ensure 24/7 reliability such as baseload gas and hydro, pumped hydro, batteries and stabilization, all of which are emissions intensive in their whole-of-life cycle and not required for a baseload electricity grid design.

While wind turbines and solar panels produce substantially less emissions over their lifetimes than fossil fuel plants, the whole-of-life emissions of batteries is said to be much higher. Preliminary studies on whole-of-life EV battery emissions are starting to appear in the literature and are also applicable to batteries used for firming renewables. This area needs much further research and analysis before definitive results can be quoted.

Section 2 of this submission concludes that the plan cannot produce a reliable service to consumers by a wide margin. Section 3, in the almost complete absence of system cost data, provides assessments that suggest the capital cost alone of the plan to 2050 is trillions of dollars which appears likely to be a massive increase on historic costs.

AEMO will have to consider whether to increase energy storage capacity or baseload back up capacity (or a combination) in its ISP in order to achieve NEM reliability. Both of these options will increase emissions.

4.3 Comparison Data Not Provided

No analysis to determine whether the emission targets are likely to be accomplished can be done since the draft 2024 ISP provides no data on estimated emissions. While the ISP claims sensitivities on the speed of decarbonisation were tested[87], there is an absence of hard data which would provide confidence.

AEMO must first address the inadequacy of the draft 2024 grid design and conduct comparative studies of alternative concepts to determine the best approach to both whole-of-system whole-of-life emissions and costs.

Without data on alternative grid design approaches, the Australian public has no means of knowing whether the goals of reducing greenhouse emissions is being achieved in a secure, reliable and cost effective manner.

4.4 Offshore Emissions

The majority of Australia's energy infrastructure is being constructed with assets manufactured offshore. In particular, China dominates the market for solar panels, wind turbines, batteries and critical materials. The energy required to process raw materials and

[87] P71

manufacture these products primarily comes from coal-fired power plants and will for the foreseeable future as China exempts itself from COP targets.

It would be disingenuous at least and dishonest to deny that these emissions should not be part of the reckoning for Australia's transition to a net zero electricity grid. Climate change effects of CO_2 emissions are only global, not local; it is therefore logical that whole-of-system whole-of-life emissions must be tallied. And whole-of-system means literally the entire grid including batteries, baseload back-up such as gas and hydro, and extra transmission lines because the only reason to include them in the grid design is to compensate for the intermittency and variability of wind and solar generation.

5 Environmental Impacts

The draft 2024 ISP takes a very high risk approach relying on social licence issues, as discussed in subsection 1, to overcome growing community concerns. Subsection 2 provides an estimate of the large land area required for solar and wind farms and new transmission lines. Disposal of large quantities of solar panels, wind turbine blades and batteries is addressed in subsection 3. Finally subsection 4 points out that the ISP does not provide any information on wildlife impacts associated with the large footprint of renewable facilities.

5.1 Social Licence

The environmental impacts of the transition of the NEM electricity grid to a renewables-dominant design have only recently started to be understood by communities through public consultative forums. As people become aware of proposals for new transmission lines, solar farms and wind farms, the scale and impacts of these projects are becoming acute.

Growing community resistance is focused on imposition of massive land use, restrictions on agriculture, wildlife impacts, and end-of-life disposal issues. The draft 2024 ISP recognizes these issues and provides more in-depth discussion of “social licence” than previous ISPs[88].

Table 2 in Appendix 8 lists four important factors which can affect social licence:

- Community expectations
- Social and cultural values
- Environmental Values
- Economic values

The first three are intangibles, which can vary considerably from place to place, time to time and relationships with others. Positive acceptance of new infrastructure can disappear in a flash due to new information and initiatives of others. The fourth issue is the “bread and butter” of how people perceive the impacts on themselves – it is the way most voters act.

Relying on social licence to ensure implementation of a vast program of infrastructure is a very high risk. Community feelings can grow to the point of taking legal actions, the results of which are unpredictable. Already, some projects have been affected.

5.2 Land Use

The land use area required by the grid design of the draft 2024 ISP is estimated to be 1.65 million hectares (16,500 km^2). This includes solar[89] and wind[90] farms and 10,000 km[91] of transmission lines.

The inadequacy of the ISP’s energy storages in the grid could require a major increase, which would have a commensurate increase in VRE to provide recharging capability.

Solar farms often displace agricultural land since its cleared condition minimizes the cost of land preparation and facilitates access both for installation and ongoing maintenance. While some types of biomass may be grown on a limited scale, most agricultural use is lost.

[88] P76 Section 8.3; Appendix 8
[89] 6 hectares/MW; https://www.powertechenergy.com.au/a/how-much-land-do-i-need-to-build-a-5-mw-solar-farm
[90] 60 hectares/MW: https://ldcinfrastructure.com.au/wind-energy-lease-explained/
[91] P11

Wind farms require a lot of space between turbines and a relatively small footprint for the turbine towers. Hence many types of agriculture and livestock can continue. However, community objections focus on potential noise effects, disruptions due to ongoing access for maintenance and visual impacts on the natural landscape. The objections to transmission lines are similar and include bushfires risks in high wind conditions.

Compared with baseload plants, the land use required is many hundreds of times larger.

5.3 Disposal Issues

Renewable wind and solar generation pose substantial end-of-life decommissioning and disposal/recycling challenges. Their relatively short life cycles – about 20 years – results in a large amount of material to be de-installed transported and processed.

Solar panels contain toxic materials such as lead, cadmium, gallium arsenide and selenium which prevents burial in land fill sites. They also can be damaged by severe hail storms.

Energy storage batteries with lifetimes of about 10 years pose a significant challenge due to toxic materials such as ionic lithium, cobalt, nickel and manganese. They also need strict safety measures to protect against dangerous voltages upon disassembly.

Large wind turbine blades, made primarily of fiberglass, are especially a problem since there are no recycling options available.

At the moment economic and practical recycling methods have not been developed. Land fill burial is the only option available. The scale of materials for disposal poses an important problem.

The draft 2024 ISP does not address disposal or recycling at all. There are large costs and additional emissions involved. This is a major oversight of the ISP.

5.4 Wildlife Impacts

Wind turbines present a mortal hazard to bat and bird populations. A wind farm on the path of migrating flocks can exact a high toll. But noise and impacts on habitat disturbance and reduced reproduction rates are also a consideration[92]. Numerous studies have been made and are continuing.

Even solar farms have impacts[93] when waterfowl mistake them for lakes in the distance and cannot take off after landing.

The draft 2024 ISP does not address wildlife issues as a necessary consideration.

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[92] https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwj6h52-kPqDAxVg3TQHHdZ1AgYQFnoECDQQAQ&url=https%3A%2F%2Fwildlife.org%2Fwp-content%2Fuploads%2F2014%2F05%2FWind07-2.pdf&usg=AOvVaw1C2FkQX5R7D0ljVCQJ7h2e&opi=89978449

[93] https://www.bv.com/perspectives/impact-solar-energy-wildlife-emerging-environmental-issue/

6 Demand Side Participation (DSP)

The nature of DSP is defined in subsection 1, not only as a remedy for protecting grid voltage stability from oversupply by excessive solar generation but also as a means of monitoring and taking control of consumer resources when frequent grid shortages occur. Subsection 2 examines the reasons why DSP is needed. Subsection 3 covers the draft 2024 ISP talk about how social licence considerations can persuade consumers to accept DSP. The realities and consequences of DSP are addressed in subsections 4 and 5 respectively.

6.1 What is DSP?

The Technical Standards for Distributed Energy Resources, adopted in February 2021 by the AEMC National Electricity Rule, laid out the requirements for upgrading grid-connected inverters to improve performance, grid security and communication interfaces to enable future growth in distributed energy resources (DER) such as consumer-owned solar panels, batteries and loads. The types of devices to which the rule applies[94] are:

"*The types of resources/assets including small and medium scale distributed generation (such as solar PV), energy storage (such as small and medium-scale batteries and electric vehicles that can deliver energy from vehicle to the power system) and controllable loads (such as air conditioners, electric storage hot water systems, pool pumps, and electric vehicle supply equipment) that connect to the distribution system.*"

The ESOO 2023 contains AEMO's 2023 forecast for DSP, which includes automated adjustments for both generation and loads. Detailed categorization, data and statistics are provided.

The purpose of the updated technical standards and the DSP are to protect the NEM grid from voltage transients and irregularities, and help balance supply and demand. It does this by monitoring and controlling consumer installations, selectively cutting off consumer PV supply when an oversupply situation (usually mid-day) threatens voltage stability, and when the NEM experiences a power shortage, it requisitions stored energy resources in batteries and EVs and/or switches off consumer loads (such as air conditions, hot water, pool pumps and EV chargers).

The NEM implements this through VPPs operated by retail energy suppliers. The scale of operation and need for timely responses are such that the entire system is controlled by software automatically via the internet and Wi Fi connections.

6.2 The Need for DSP

The need for DSP and WDR (Wholesale Demand Response for businesses) to support the grid with "consumer resources" is testimony to the lack of proper systems engineering design and planning in the draft 2024 ISP.

The need to shut down the connection of consumer solar panels to the grid – just when the consumer has surplus energy to sell to lower their bills – is solely a manifestation of a design

[94] Page 4 AEMC National Electricity Amendment (technical Standards for Distributed Energy Resources Rule 2021) Section 1.2.3 Definition of DER and Connected DER

reliant on literally millions of home PV installations and a gross lack of energy storages to soak up the surpluses. The need to requisition stored energy in consumer batteries and EVs is a result of building an unreliable electricity grid primarily with intermittent and highly variable renewable energy generation.

The fundamental purpose of utilities, such as electricity and water, is to serve consumer needs as and when they are needed. Simply put, DSP and WDR are an inversion of this purpose.

That planning and implementation of DSP and WDR has been underway for several years is evidence of third world thinking from the start of the transition. As Section 2 of this submission reveals, the new NEM grid has been designed with insufficient generation resources with the result that frequent shortages will occur.

Events in recent years when AEMO has been forced to issue LOR (Lack of Reserve) warnings to the public and ask them to restrict use of energy for heating and air conditioning – just when it is needed most – is a harbinger of serious blackouts to come, on a scale that will overwhelm any effect that DSP can mitigate.

6.3 Social Licence for DSP and WDR

The requirement for consumers to actively support the grid appears to have been approached with some trepidation by planners. 'DSP' appears only once in the draft 2024 ISP text – in the Glossary (and in Figures 2 and 14). Instead Appendix 8[95] camouflages it by calling it "*consumer mobilization, adoption and orchestration*".

Social licence concerns in the draft 2024 ISP reflect significant uncertainty as to how to persuade consumers to participate willingly in supporting the grid.

Section 8 of the draft 2024 ISP identifies the risks[96] that "CER are not adequately integrated into grid operations". It describes "*significant system benefits*" firstly by owners signing up to VPPs and secondly by VPPs being integrated into the NEM ('orchestration'). The ISP also acknowledges that "*owners would need to see the benefits of orchestration, overcoming both technical complexity and a lack of perceived value… then trust the energy sector to deliver those benefits*."

Appendix 8[97] also acknowledges that "*…the energy sector must gain consumer trust and confidence to enable orchestration in the future*….*There are several barriers to gaining consumer trust and acceptance, including an existing lack of trust in institutions and organisations, differing motivations, complexity, lack of perceived value and high perceived costs.*" But benefits accruing only to the NEM system are unlikely to be perceived as personal benefits.

6.4 The Reality of DSP

The reality is that AEMO is planning a future NEM that firstly, is dependent to a substantial degree on consumer solar power inputs (61% of all solar and the largest share 36% of all

[95] P16 Appendix 8
[96] P76
[97] P17 Appendix 8.3.2 Social Licence for CER Orchestration

power generation by 2050) and secondly, in the future it will depend on stored energy of consumers willingly shared in times of frequent NEM power shortages and acquiescence to automated curtailment of consumer loads.

Human nature is to hoard resources in times of uncertainty and stress. DSP will need to overcome this behaviour on a broad scale through social engineering. Motivation based on appeals to higher virtues in the short term may have limited success but it is not only difficult to achieve but also unpredictable and therefore not reliable in the long term.

Voluntary sharing, when faced with shortfalls in effectiveness, will result in the temptation for mandatory imposition of DSP and WDR. VPPs, which are a form of small scale voluntary collectivisation, could give way to future forced collectivisation with all of the historical fears that implies.

Mechanisms with which to encourage consumers to share resources can involve not only goodwill but also money, both as reward and punishment.

Goodwill can disappear in a flash if people lose confidence in the energy system when it becomes obvious that shortages are being deliberately designed into the NEM. People also become resentful when others may not be doing the same. In the longer term, people may see that touted benefits for consumers are illusory; their participation is really just sacrifices to prop up an ill-designed power grid.

Money, the currency of markets, is far more effective at enlisting participation in a scheme. Residential owners and businesses would not be willing to invest in solar installations were it not for the large subsidies and lure of power bill reductions. In California last year, a 50% scale back in subsidies saw an 85% reduction in home installations. Subsidies have worked very effectively in the initial years of transition but as numbers grow, two effects on consumers become unavoidable.

1. The cost of subsidies (paid by consumer through taxes) becomes too large for governments to ignore and they begin to diminish.
2. The amount of consumer solar available to the grid overwhelms daytime demand causing wholesale prices to plummet (as has become a common occurrence already) – the result is a dramatic fall in feed-in tariffs, which reduce consumer power bills.

The use of money as punishment is far more effective. In basic economic theory, high prices reduce consumer appetite for consumption. Taxes and tariffs not only reduce disposable income but, as the current inflationary times well show, it causes great stress on consumers unable to pay mortgages, electricity bills and food. Unfortunately this is a lowering in standards of living.

The draft 2024 ISP discusses the 24 hour cycle of electricity demand in terms of using time-of-use (TOU) tariffs[98] to 'encourage' consumers to move away from 'convenience charging' of EVs to adopt "smarter charging patterns" to use energy during the day when large surpluses of solar power are often available (when wind and solar droughts are absent). (The

[98] P9,10 Appendix 4.2

amount of energy storages in the NEM plan are insufficient to 'soak up' these surpluses so they can be used overnight.)

EV charging is expected to add considerable demand and at least one survey[99] (2022) showed that most consumers, by a large margin, preferred overnight recharging when most are not actively using their vehicles. Unfortunately this coincides with the time when other demands peak, solar is zero and wind can be in drought – as addressed by Section 2 of this submission.

TOU tariffs are a punishment for using energy at a time when consumers most need it. It has disproportionate impacts on the poor rather than the rich, who can safely ignore their power bills.

Regarding EVs, which are being actively encouraged by governments through subsidies, the draft 2024 ISP unrealistically expects that despite most owners typically suffering from 'range anxiety' they will gladly use their EVs as contributors to the NEM as part of VPP resources. This contribution is most likely required in evenings when EV batteries are most likely to need replenishment due to active daytime use. This plausible outcome cannot easily be dismissed.

TOU tariffs will require employers and carparks to install massive amounts of recharging facilities which will overload local grids necessitating costly upgrades to transmission lines and distribution networks. Who will pay for this impact?

6.5 Consequences of DSP

The ongoing implementation of DSP and WDR measures is not widely understood by the public. Once the realization becomes common, there is a real risk it will be seen as an Orwellian solution to an unreliable NEM. Confidence and trust in the energy industry and government will suffer accordingly.

DSP may have numerous consequences:

- Uncertainty in scale of DSP effectiveness - it is very small compared to power deficits and not worth the trouble and effort
- Uncertainty in human behaviour: DSP cannot be used as reliable dispatchable power as indicated in Figures 2 and 14 which include it – unless it is made mandatory
- Consumers will reject a system that lowers their EV battery overnight below what they need the next day; they will reject lowering their home batteries in the face of frequently recurring grid shortages
- Widespread perception of a weak, unreliable grid if frequent blackouts eventuate as predicted
- Lowered trust in government and the energy industry
- Disincentive for business investment leading to lower job opportunities and less economic growth
- The full impact, yet to be understood by the wider community, will provoke severe backlashes to Australia's international reputation for a modern economy

[99] Philip et al, Driving and Charging an EV in Australia: A Real world analysis, UQ, 30 September 2022

7 National Security

While it is not the responsibility of this submission nor AEMO to pass judgement on national security issues, it is nevertheless a citizen's duty to identify risks to national security and pass them to government for appropriate evaluation. Subsection 1 lists the potential impacts of the draft 2024 ISP on national security and subsection 2 is a brief overview of the geostrategic context for Australia. Subsections 3 to 5 address issues concerning economic impacts, military preparedness and cyber-attacks respectively.

7.1 Three-Fold Impacts

The draft 2024 ISP poses three types of risks to national security:

1. An unreliable and costly electricity grid, as assessed by this submission, will considerably weaken the entire economy for a generation making unaffordable the full range of means to protect Australians.
2. An electricity grid, predominantly built with products and materials made in China, greatly magnifies the risk of economic coercion, trade sanctions and interference.
3. The integration of homes and businesses into the power grid via internet connections greatly increases the nation's vulnerability to cyber-attack, which is already a major problem and is amplified by item 2 above.

These risks, by themselves, call for a complete rethink of the draft 2024 ISP.

7.2 Geostrategic Trends

In the last decade, world-wide trends have seen increasing geostrategic competition and hostilities. Slowly and not well recognized at first, these threats have emerged causing wide-spread concern among western nations. Some commentators liken the present situation to the 1930s, when revulsion from the trauma of World War I led to pacifism and unpreparedness among democratic countries.

Australia's position in the Indo Pacific region exposes it to tensions originating from China's aggressive behaviour. These threats include trade sanctions against Australia, military build-ups in the South China Sea, hostile actions towards Australian aircraft and ships, large scale cyber-attacks, interference in domestic affairs, growing influence with south Pacific island countries and overt threats against Taiwan.

Australia's small population, rich resources and military unpreparedness leads to insecurity. Alliances with other western countries that are at a far distance go only part way to allay concerns. What matters is that Australia increases it efforts to harness its rich resources, talented population and makes decisions which increase the nation's resilience.

The Defence Strategic Review 2023 identified threats to Australian sovereignty and prescribed actions to mitigate them.

Global trends suggest that tensions will increase in the foreseeable future. Australia must prepare itself for realities based on evidence rather than hopes.

From the point of view of the proposed transition to a renewables-dominant electricity grid, this assessment requires a close focus on three factors: economic strength, military strength and protection from cyber-attack.

7.3 Economic Impacts

It is self-evident that economic strength is a vital key to maintaining the sovereignty of the nation. Without it, a country cannot afford to invest in the military and economic means to independently survive.

The draft 2024 ISP poses two significant economic security risks: an unreliable and costly electricity system, as assessed by this submission, and an overdependence on one source of products and materials for building the NEM.

Few would dispute that an unreliable and costly electricity grid would weaken the entire economy. That is the inevitable result when the plan is massively deficient in reliable dispatchable power generation, when the plan requires either unaffordable energy storages or a complete duplication with baseload power generation and when the plan depends on the goodwill of all residential and business owners to voluntarily install and share resources with a grid that is prone to blackouts.

An electricity grid made largely with products and materials, for which China dominates global markets, greatly magnifies our risk of economic coercion and trade sanctions. The implications for national security are serious. The NEM system design is dependent on equipment imported from a country that does not share Australian values, has already been identified as a geostrategic risk and which has already enacted trade sanctions against Australia. A wave of EV imports from China, which is already a dominant global supplier is another issue raising concerns here and overseas.

7.4 Military Self-Sufficiency

Australia’s military capabilities need significant expansion to deter future aggression and contribute to alliances, which underpin Australia’s security. The AUKUS agreement is a major long term step towards this objective.

The nature of military operations on the sea, in the air and on the ground involve the absolute need for large amounts of energy, instantly available when needed. Fossil fuels uniquely provide this capability and will never be displaced by electrification.

Military command and control cannot function without reliable 24/7 electricity at all facilities. Critical facilities are necessarily equipped with diesel-powered back-up generators but the wider operations of the Defence Department remain dependent on a reliable supply of electricity.

While Australia possesses large reserves of gas, most of the oil-based products on which military operations depend are sourced overseas, which exposes the nation to interdiction of supply in times of tension. Significant domestic storages are badly needed but building a strong military capability is ultimately the only way to deal with the threat of interdiction.

7.5 Cyber Risks

The draft 2024 ISP, including all appendices, mentions the word cyber just once – in passing. Given the on-going and increasing cyber assaults from both state and non-state actors in the past decade, it is unfathomable that such an important subject be overlooked.

This deficiency must be addressed by the ISP. The pervasive and growing threats from daily cyber-attacks on governments, businesses and organisations, is a real and present danger. The implementation of DSP via an entire grid network, dependent on internet connections, is an obvious vulnerability that is greatly enhanced by dependency on China for the majority of equipment installed in the NEM.

The use of Chinese products in Australia's telecommunication networks has already been restricted; Chinese-made security cameras in key government facilities are being removed. The risk from malware installed in Chinese-manufactured products used throughout the future NEM is obviously very high.

China's growing exports of cheaper EVs, which are heavily loaded with software and communications technologies, is another facet of this risk.