1. If Australia continues down the ‘renewables only’ energy plan which has been outlined by AEMO’s *Step Change* scenario and adopted by the Albanese Labor Government, will energy prices increase?

Yes, energy prices will inevitably increase if Australia continues down the ‘renewables only’ energy plan outlined by AEMO’s *Step Change* scenario.

First, this can be established beyond doubt by assessing the claims of the Integrated System Plan (ISP) with care, and examining the cost of the constraints AEMO has imposed on the model; including the shadow carbon price. It is important to note the difference between a system’s cost, as modelled, and the price a market participant must be paid to deliver that energy. This differential requires a brief discussion of risk, return, and uncertainty. Another important question to address is whether prices are divorced from costs, by means of pushing large parts of the cost onto taxpayers, or consumers, rather than through prices of a user-pays system.

Second, the limitations in the ISP’s scope, shortcomings in its methods, and doubt about its assumptions pushes the likelihood and extent of price increases far higher. At least three unrealistic assumptions inherent in the ISP model mean prices will rise even higher than suggested by the shadow carbon price: the exclusion of Consumer Energy Resources (CER) costs; exclusion of end-of-life costs; and the reliance on ultra-flexible hydrogen electrolysers.

If Australia continues down the ‘renewables only’ energy plan outlined in *Step Change*:

- the total costs of our energy system will rise;
- the increased risks and uncertainties associated with very high weather-dependence will mean prices will rise at least as quickly as costs or faster;
- the extent of subsidies or other cost-shifting mechanisms required to compensate for the unavoidable increases in cost and price are so large and uncertain as to be effectively unbounded. Cost-shifts of this nature should not be contemplated when attempting to have an evidence-based discussion of future energy prices.

The ISP’s claims and cost of modelling constraints demonstrate prices will increase

When properly understood and accurately cited, the Integrated System Plan and the *Step Change* scenario are consistent with the proposition that building an energy system almost entirely dependent on sources of energy that are dispersed, intermittent and uncontrollable is an expensive and difficult exercise. The ISP demonstrates that such a system will require vast amounts of machinery used inconsistently; with most being used at less than half their full capacity, and some barely used at all. This is a recipe for an expensive system. The size of the system will be much larger than a system with a small amount of machinery used to produce a lot of power consistently.

The proposition that a much larger system can have lower total system costs than a smaller one relies on an enormous cost differential between the types of machinery involved in the two systems. Proponents of a renewables-dominated system often claim that the lack of fuel cost and relatively low capital cost for wind and solar meet and exceed this differential.[1] There is abundant evidence — including the current state of electricity bills — that this differential has not been met, as we’ve ventured from a historically coal-dominated system to a renewables-dominated one.[2] This matches the overwhelming trend of significantly higher costs in other countries or jurisdictions that have attempted to reach very high levels of wind and solar in their energy mix.[3] Outliers that resist this trend are exceptional rather than systemic, and tend to result from quirks of geography; such as particularly strong endowments of flexible firming from hydro power.[4]

Academic analyses that suggest electricity costs under a wind- and solar-dominated system might be noticeably lower than we have today rely on either the exclusion of significant parts of the system, or the assumption that most prices for a weather-dependent system's machinery will fall significantly in the future, or both.[5]

Much of the machinery in the ISP's proposed system is not falling in price, and there is no reason to expect it will do so in the near future (e.g. transmission,[6] gas peaker plants,[7] gas pipelines and storage,[8] pumped hydro,[9] offshore wind,[10] synchronous condensers[11]). Other elements of the system have failed to fall at anything like the rate expected (e.g. batteries,[12] hydrogen electrolysers[13]). Some major parts of the weather-dependent system that were assumed to fall in price or at least plateau[14] have in fact started to increase, due to irreversible factors (e.g. onshore wind, which is facing increasingly less favourable choice of location[15]).

The ISP is frequently cited to counter the well-supported proposition that smaller, more consistently utilised systems end up costing less. However, the ISP, even accepting many dubious assumptions, does not provide evidence to the contrary. It conducts no suitable experiment to assess whether a smaller or larger system will cost less, as it models only a renewables-dominated system.[16] No comparison is permitted with a system that has larger shares of energy from controllable, synchronous generation sources such as nuclear, coal, or gas.[17] The CEO of AEMO has made it clear he can give no assurances that prices for consumers will go down.[18]

Claims or inferences to the contrary have persistently been made by members of the current government as well as public officials. An exemplar of this situation would be a sequence of statements made by the Chair of the Climate Change Authority, Matt Kean, before Senate Estimates. Kean's insistence that "the ISP is a look at the counterfactuals as to other sources of generation to provide the cheapest replacement cost of an existing system"[19] epitomises the common misrepresentation of the ISP.

Contrary to Kean's assertion, the ISP's Counterfactual development path is bound by the same policy constraints and assumptions as the Optimal Development Path, including the 82% renewable energy target, an exclusion of nuclear, new coal or coal refurbishments, a tight carbon budget, and many other targets and projects determined by various state governments.[20]

The evidence provided by AEMO to the Senate demonstrates that the ISP's constraints — particularly those that prevent it modelling a higher level of controllable, dispatchable power such as coal or gas — do impose a cost on the electricity system as modelled, and that this cost will increase in future years. In answer to a Question on Notice, AEMO has confirmed that in 2050 the shadow carbon price in the *Step Change* Scenario will be $256/tonne.[21] This is a significant cost, and is evidence that the constraints on the ISP necessitate higher electricity prices under a user-pays model than an unconstrained model would.

It is difficult to quantify the precise impact on bills under *Step Change* from this answer alone. This is because the shadow carbon price reflects the marginal rather than average cost of a given constraint and there are a number of other constraints on the model such as renewable energy targets, so the shadow carbon price is not always the most binding constraint.

However, given the magnitude of the number, and the fact that it increases over time under the *Step Change* projections, it cannot be argued that the modelling constraints have no cost. Unless one attempted to argue that the system we have today — and had 10 or 15 years ago — is in a fundamentally more constrained state than the one we're projected to move towards under the *Step Change* scenario, the increasing constraints will force the total cost of the system higher. Such an argument seems entirely implausible, given the escalating constraints relating to renewables shares and carbon budgets modelled in *Step Change*, and the relative absence of these constraints today and in the past when prices were lower.

Indeed, in recent Senate hearings, questions about power prices were put to both official government agencies (such as the AEMC[22]) and think tanks generally committed to arguing that nuclear is more expensive than renewables (such as the IEEFA[23]). Neither could give a feasible explanation for the long-run trend of increasing power prices in Australia. The Ukraine war was the only alternative catalyst offered, but this cannot account for the long-run trend of price increases before and after the war's short-term impacts were felt.

The question of cost-shifting out of the current system

The question above addresses energy prices. In a technical sense, it is possible to reduce the price of a product by forcing the price paid to diverge from the underlying cost. This is typically done through direct subsidies and rebates. The federal government and some state governments have already taken significant steps in this direction, by subsidising dispatchable generators to function in ways that would not be commercially viable,[24] as well as direct government rebates off electricity bills.[25]

Another way of shifting costs out of the ISP's proposed system is to assume that investors, including households, will shoulder significant costs without any evaluation of the likelihood they can get a sustainable return. The most obvious instance of this is Consumer Energy Resources, and a flexible hydrogen industry. See below for a discussion on these excluded costs and how the ISP assumes subsidies far greater than any contemplated in recent history.

The only way to have a meaningful and evidence-based discussion of future energy prices is to maintain the assumption that the system remains essentially user-pays. Contemplating the expansion of subsidies and cost-shifts to the scale presented in the ISP only serves to undermine the debate.

The difference between cost and price — risk, return and uncertainty

The ISP attempts to model the system's *cost* in the *Step Change* scenario. This is based on the assumption that prices generally tend to follow costs. We have separately discussed a possible exception — that costs might be shifted away from the market and onto taxpayers. Another possible exception remains for services that are modelled within the market framework: the margin expected by investors in order to cover costs and make a reasonable return.

The question of what constitutes a reasonable return is a question of risk. Riskier investments demand higher returns. This becomes incorporated into investors' expected return on equity — and debt — for a given investment.

The inherently unreliable nature of weather-dependent energy necessarily drives increasing risks and uncertainties for investors. This phenomenon has remained hidden with relatively low penetrations of renewable energy. However, since the capture prices in the wholesale spot market for wind and solar have become noticeably depressed (Figure 1[26]), there is now substantially greater risk that investors will be unable to get reliable take-off agreements for their energy. This situation has already become a reality in Australia, as shown by the launch of the Capacity Investment Scheme, which will use taxpayer funds to underwrite investors' renewables projects.[27]

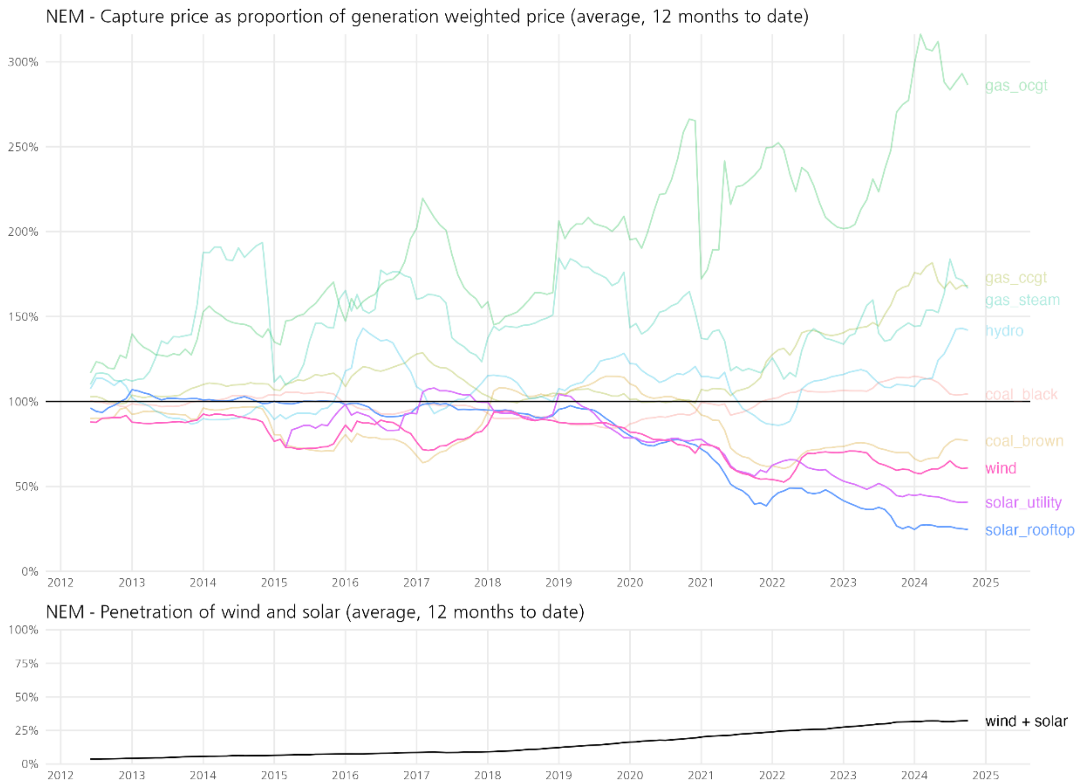

Figure 1. Capture prices for wind and solar as a proportion of generation weighted price have decreased with increasing wind and solar penetration.

Other types of investment — including those required to provide firming, such as gas or coal — also become much riskier in the *Step Change* scenario. Indeed, it is acknowledged new mechanisms will be required to support investment in higher levels of gas capacity that would be rarely used.[28]

Increased risks from changing economic and planning requirements are currently impacting projects reliant on Renewable Energy Zone (REZ) infrastructure. One example is the Central West Orana REZ, initially forecast to cost around $650 million,[29] and now expected to cost over $5 billion, with construction yet to start.[30] Investors in two major wind farms in the REZ have already paused or cancelled projects, presumably because of the increase in connection costs.[31] Any mechanism to expose developers to a share of commensurate costs for supporting infrastructure substantially increases risk for investors.

Risks for investors arising from uncertainties tied to supporting infrastructure will only increase as more wind and solar farms are built. Dispatchable, synchronous sources of power require only a modest and predictable amount of transmission to support a reliable electricity system. Wind and solar, on the other hand, require an expanding set of complementary investments in transmission, storage, gas firming, and other services to provide system strength and security. Any risk arising in one part of this deeply co-dependent system necessarily introduce risks to other parts of the system. This only serves to increase overall risk and uncertainty perceived by investors. It therefore seems implausible that margins will reduce, allowing prices to squeeze closer to system costs, since increasing risk and uncertainty will tend to attract a premium in the margins expected from investors.

Unrealistic assumptions inherent in the ISP model mean even greater prices rises

Costs for Consumer Energy Resources excluded from the ISP

The ISP relies heavily on consumer energy resources (CER) such as rooftop solar, home batteries, and EVs to provide generation and storage in coming decades but excludes the costs of these assets to the system.

Under *Step Change*, rooftop solar makes up the majority of solar capacity in the grid (a four-fold increase on current levels by 2050) and consumer batteries make up the majority of storage capacity by the 2040s (a 30-fold increase on current levels by 2050).[32] One analysis suggests this amount of rooftop solar and consumer batteries in the system would cost on average more than $39,000 per customer.[33] Yet, AEMO does not include these costs in their annualised capital cost figure of $122 billion for the *Step Change* scenario.[34]

The cost to taxpayers of government subsidies is also excluded. The Green Energy Market report that underpins the ISP's forecast accelerated uptake of batteries depends on the assumption that the federal government will provide rebates equivalent to half a battery's value.[35]

Excluding the cost of CER represents a significant omission in the ISP. The 2024 *Step Change* scenario requires the installation of an average of 3.1 GW of new rooftop solar capacity and 9.1 GWh of new consumer batteries annually from 2024-25 to 2049-50.[36] Using 2023-24 GenCost capital cost figures, CIS estimates the total capital cost for CER over this period to be approximately $347.5 billion.[37] This is significantly higher than the estimated $83 billion capital cost for large-scale solar and batteries up to 2050, which the ISP includes.[38] In net present value terms, CER capital cost equates to $121 billion, annualised to 2050.[39] Given that adding this to the total nearly doubles the $122 billion headline capital cost figure reported in the ISP, omitting this figure significantly distorts the true cost of the renewable energy transition depicted in the *Step Change* scenario.

The ISP also excludes the costs of coordinating CER storage — such as through Virtual Power Plants (VPPs) or charging and discharging EVs at times that suit the grid rather than consumers. This is despite the ISP assuming most CER storage available to the grid from the 2030s onwards will be coordinated.[40] AEMO has made the assertion that the "optimistic outlook for coordinated CER storage" will require "continual reforms of tariffs, market incentives and policies"[41] — but AEMO has not estimated the cost of government subsidies assumed to be available in the ISP model. Financial incentives are clearly needed to convince consumers to allow their batteries to be coordinated, as the coordinated CER trial Project EDGE found that almost half of consumers had little to no interest in joining a VPP.[42]

Significant capital expenditure will also be required to upgrade distribution networks to ensure grid stability as CER installations grow. The cost of distribution network upgrades is significant, with an Energeia project paper estimating the total cost of mitigating over-voltage

— when voltage goes above the design limit of the grid — due to solar installations over the next 20 years as being between $0.7 to $1.1 billion, depending on the level of CER adoption.[43] Yet, the ISP does not take these costs into account.[44]

Electricity prices are already being pushed up by rooftop solar because consumers who do not own solar systems cross-subsidise those who do. Rooftop solar customers earn outsized savings of around three times the 4c/kWh value they provide to the grid through averted coal and gas costs.[45] This is because of the way network costs are passed onto consumers. Distribution Network Service Providers (DNSPs) recoup 60-75% of their fixed costs through variable charges or 'tariffs', which retailers typically pass on to consumers as variable usage rates.[46] But rooftop solar owners are able to avoid paying these usage rates – and the network charges they contain – through self-consuming their solar output during the day. They also receive outsized earnings from most retailers through high export reward tariffs.[47] This shifts the burden of paying network costs onto consumers without rooftop solar, meaning electricity rates must increase for everyone so DNSPs can recoup all of their costs.

These additional CER costs not included in the ISP will contribute to higher electricity prices than indicated by the total costs AEMO quotes for *Step Change*.

End-of-life costs excluded from the ISP

The ISP excludes the full costs of decommissioning and recycling wind turbines, solar panels and batteries.

For solar panels and onshore wind turbines, the ISP included retirement costs but excluded recycling costs.[48] For batteries and offshore wind, retirement costs of any kind were entirely excluded from the modelling due to "insufficient data available at the time of the 2018 GHD report", which is an input to the ISP.[49]

The omission of disposal and recycling costs essentially means the ISP has assumed all waste from solar panels, wind turbines and large-scale batteries is either abandoned on-site or taken to landfill at no cost. This is unrealistic, given Australia's legislative environment is increasingly making recycling the only option. In Victoria and South Australia, solar panels and batteries have been banned from entering landfill and must be recycled or stored until they can be recycled.[50] Western Australia has announced similar restrictions and the federal government is also developing a mandatory product stewardship scheme, which could make solar panel manufacturers and importers liable for recycling costs.[51] Queensland has recently announced a solar panel recycling pilot scheme that will inform the national scheme.[52]

Current costs of recycling solar panels are around $28 per panel, roughly six times the cost of sending solar panels to landfills;[53] so mandated recycling will increase the overall cost of panels. Offshore wind has significant end-of-life costs, with a 2.26 GW Belgian offshore wind farm having net decommissioning and recycling costs of almost A$1.2 billion.[54]

These additional end-of-life costs not included in the ISP will contribute to higher electricity prices than indicated by the total costs AEMO quotes for *Step Change*.

Hydrogen electrolysers used as a flexible solar sink in the ISP

The ISP uses hydrogen production as a flexible solar sink while assuming the hydrogen storage required to do this is free. AEMO themselves note that hydrogen capacity “could be substantial but depends on the development of domestic and global hydrogen industries”.[55] If the sector does not develop as expected, the system would likely be more costly than modelled and require additional measures to stabilise midday demand.

The ISP projects that hydrogen electrolysers will operate only when power is abundant (generally at midday) and avoid running on cloudy or windless days when wind and solar production is poor.[56] This makes the modelled system cheaper and lower cost.

Unfortunately, hydrogen use cases expect constant supply, and the model effectively assumes the storage required to make the intermittent supply into constant supply is free.[57]

Moreover, the ISP model balances hydrogen production over monthly timeframes, which also requires significant storage, as noted by submissions to the ISP: “most hydrogen use cases identified by Climateworks and CSIRO require a constant supply of hydrogen and there is no evidence base supporting the monthly balancing assumption without a significant volume of storage”.[58]

To address these concerns, AEMO created a “low hydrogen flexibility sensitivity” where instead of satisfying a monthly hydrogen production target, it satisfies a daily target. The sensitivity finds that $6.5 billion spent on another 7 GW of solar, 1 GW of flexible gas and 1.8 GW of utility-scale electricity storage allows the model to meet these daily targets instead of monthly ones. It also finds a relatively minimal impact on the weighted net benefits ($200 million) and on the net benefits of *Step Change* ($500 million).[59]

However, having a daily target still means the ISP model assumes hydrogen production can load-follow solar output — i.e., on sunny days, production would occur during daylight hours and ramp down overnight. This gives a low capacity factor, which would be uneconomic for hydrogen production. Instead, an 80-90% capacity factor should be assumed, meaning hydrogen production would not act as a solar sink and load-follow during the day as assumed by the ISP model.

Ultimately, not having hydrogen electrolysers available to soak up excess solar energy supply during hours of peak solar output will result in more energy being spilled. This will increase prices for the remaining unspilled energy, as the same capital costs will still need to be recouped across fewer MWh of generation, ultimately contributing to higher electricity prices than indicated by the total costs AEMO quotes for *Step Change*.

2. If Australia continues down the 'renewables only' energy plan which has been outlined by AEMO's *Step Change* scenario and adopted by the Albanese Labor Government, will energy reliability be compromised?

Yes, energy reliability will be compromised if Australia continues down the 'renewables only' energy plan outlined by AEMO's *Step Change* scenario.

This is because the ISP model is not designed to guarantee reliability up to current standards when exposed to real-world variability. As the Manager of the Economics and Modelling Team in DCCEEW's Office of the Capacity Investment Scheme, Zoe Konovalov, confirmed in an August 2023 webinar:

> …the original intent of the ISP [was] an exercise in transmission planning. It was not ever intended to be an exercise that would give you reliability requirements across jurisdictions. The modellers at AEMO that we talked to are very clear-eyed about the kind of roles of the various modelling exercises that they undertake.[60]

Two aspects of the ISP model specifically prevent it from ensuring grid reliability to the current standard — the model's 'perfect foresight' of the weather and the inability of gas peaking plants to operate as assumed.

Perfect Foresight of the Weather

AEMO has acknowledged the ISP model assumes perfect foresight of the weather, which results in gas capacity expanding 'just in time' for bad weather years:

> AEMO acknowledges the impact of perfect foresight on modelling outcomes over both the short- and long-term horizons. AEMO accepts that perfect foresight over the long-term horizon results in pre-emptive expansion for the underlying weather sequence used to drive the model, and that in reality the weather cannot be known in advance.[61]

Rather than ensuring the ISP model is prepared to withstand the 'worst' weather possible — within given bounds of probability — every single year, AEMO "tests numerous alternative weather sequences in the ISP capacity outlook model and selects a 'typical' sequence in terms of outcomes such as transmission and generation development to ensure the sequence chosen is not resulting in an outlier outcome".[62] But it is not a typical year that will matter for reliability. It is an outlier year with very low solar and wind output, in which blackouts will occur unless sufficient generation and firming infrastructure is built.

Under the ISP model, storage operators also enjoy the benefits of perfect foresight to optimise charging and discharging.[63] In reality, this would not occur. Batteries may have very little charge left when a sequence of bad weather days hits due to their imperfect foresight of the weather, threatening system reliability.

By assuming perfect foresight in the modelling, the ISP *Step Change* scenario cannot guarantee reliability to current standards. If weather sequences transpire that reduce wind and solar output more than modelled for the ISP's 'typical year', reliability will be compromised.

Peaking Gas will not operate as assumed

The peaking gas infrastructure assumed to be available in the ISP to support renewables is unlikely to eventuate, given commercial viability and engineering considerations.

The federal government's review of the ISP acknowledges that "the gas developments needed to satisfy the ISP assumptions may not be likely or commercially feasible, meaning that AEMO is assuming gas will be available to service gas-fired power generation that the gas market might not be able to deliver at the price or quantity assumed".[64]

This is confirmed by extensive modelling of the interaction between the gas and electricity systems performed by Paul Simshauser and Joel Gilmore:

> Gas infrastructure has been sized to serve mainly residential and industrial demand, and may not be compatible with the power system firming task ahead.[65]

Simshauser and Gilmore found significant shortfalls in gas supply due to surging maximum demand, pipeline constraints due to the current network configuration, and exhaustion of gas storages due to episodic demand shocks on bad weather days.[66]

Since the ISP does not co-optimise the gas market with the electricity market, it cannot guarantee its gas capacity and availability projections are reasonable or likely to eventuate. Failure to realise the *Step Change*'s gas projections would result in a lack of sufficient generation during extended bad weather periods, compromising system reliability.

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[36] The calculation assumes that rooftop solar has an operational life of 30 years, while consumer batteries last 15 years, meaning they will need to be replaced periodically to maintain capacity over ISP's projection period, thus adding to the new capacity installed.

[37] The $347.5 billion total capital cost for CER is calculated by multiplying the new capacity of rooftop solar and consumer batteries installed under the *Step Change* scenario by the projected capital costs based on available data in 2023-24 GenCost. For rooftop solar, GenCost provides annual capital cost forecasts, which we used to project the total capital costs over the period. For consumer batteries, however, GenCost does not provide a forecast of future costs. It reports the current installation cost at $1,455/kWh (p. 58). As a result, we assumed this installation cost remains constant throughout the projection period for calculating the total capital cost of consumer batteries. If the learning rate of 1-hour utility-scale battery is applied to small-scale battery, this would reduce the total capital cost for CER to $211 billion.

[38] As the ISP does not provide a detailed breakdown of generator and storage capital costs, we estimated the $83 billion by calculating the annual increase in utility solar (GW), deep storage (GWh), medium storage (GWh), and shallow storage (GWh) in the *Step Change* scenario. These annual capacity increases were then multiplied by the corresponding capital costs from the 2023-24 GenCost report to derive the total capital cost for large-scale solar and batteries up to 2050.

[39] Calculated using the same 7% discount rate adopted in the 2024 ISP.

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[44] AEMO. 2024 ISP. p 13.

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[55] AEMO. 2024. 2024 ISP Appendix 4: System operability. p 12.
[56] Ibid.
[57] AEMO. 2024 ISP Consultation Summary Report. p 53.
[58] Ibid.
[59] AEMO. 2024 ISP Appendix 6: Cost Benefit Analysis. p 114.
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