AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

2021 Inputs, Assumptions and Scenarios Report

December 2021

Addendum

For use in Forecasting and Planning studies and analysis

Important notice

PURPOSE

AEMO publishes this addendum to the 2021 Inputs, Assumptions and Scenarios Report (IASR) pursuant to National Electricity Rules (NER) 5.22.9. This report includes key information and context for the inputs and assumptions used in AEMO's Forecasting and Planning publications for the National Electricity Market (NEM).

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VERSION CONTROL

Version	Release date	Changes
1.0	10/12/2021	Initial release

Contents

1. Introduction

In 2019, reforms to the National Electricity Rules (NER) and the National Electricity Law (NEL) converted AEMO's *Integrated System Plan* (ISP) into an actionable strategic plan. As part of this, the Australian Energy Regulator (AER) is required to review the transparency of inputs and assumptions determined by AEMO in developing the ISP[1]. The role of the transparency review process is to provide a view on AEMO's explanations of its derivation of key inputs and assumptions in the IASR.

This addendum to the *2021 Inputs, Assumptions and Scenarios Report* (2021 IASR) provides further explanation about how AEMO derived the ISP parameters highlighted in the AER's transparency review[2] published by the AER in August 2021.

The transparency review found the IASR to be comprehensive

The transparency review concluded that the majority of AEMO's inputs and assumptions have been adequately explained and that AEMO has demonstrated that it has taken into account stakeholder feedback. The review summarised this position by stating that "*AEMO has taken into account key uncertainties in the development of its scenario narratives and has undertaken a comprehensive assessment of the ISP parameters relevant to each scenario*".

Further explanation of some topics will improve transparency

In addition to the overall finding, the AER's transparency review required AEMO to provide further explanation in regards to the following parameters, and to consult on these matters in the Draft 2022 ISP:

- Multi-sectoral modelling (see Section 2).
- Distributed energy resources (DER) projections (see Section 3).
- Government policy assumptions (see Section 4).
- Forced outage rate projections (see Section 5).
- System security assumptions (see Section 6).
- Capital cost assumptions (see Section 7).
- Thermal coal plant assumptions (see Section 8).

[1] NER 5.22.9(a)

[2] AER. *Transparency Review Integrated System Plan 2022 Final Inputs, Assumptions and Scenarios Report,* at https://www.aer.gov.au/networks-pipelines/performance-reporting/transparency-review-of-aemo-2021-inputs-assumptions-and-scenarios-report.

1.1 Invitation for written submissions

All stakeholders are invited to provide a written submission on any aspect of the Draft ISP, including the content within this addendum. Written submissions should be sent in PDF format to ISP@aemo.com.au by 11 February 2022. Additional information on upcoming engagements is available on AEMO's website[3].

1.2 Process to develop the 2022 ISP

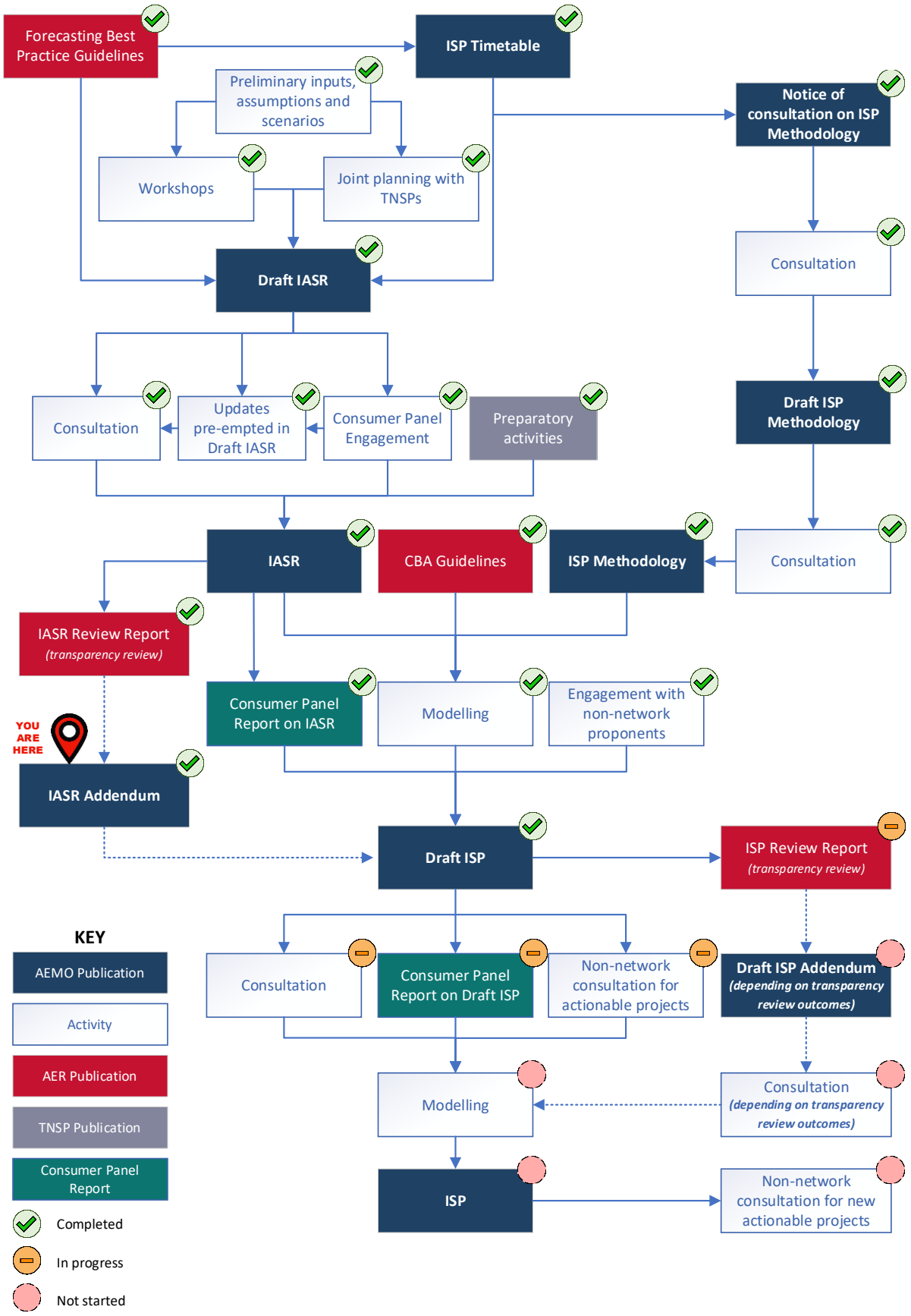
This document is published as part of the 2022 ISP[4]. 0 below provides a visual representation of this process, including both the elements of the regulatory framework (in blue, red and green boxes) and the activities undertaken by AEMO and stakeholders (in white boxes).

The remainder of this document sets out further explanations to parameters identified within the AER's Transparency Review.

[3] AEMO. *2022 ISP – Opportunities for engagement*, at https://aemo.com.au/energy-systems/major-publications/integrated-system-plan-isp/2022-integrated-system-plan-isp/opportunities-for-engagement.

[4] AEMO. *Draft 2022 ISP*, at https://aemo.com.au/energy-systems/major-publications/integrated-system-plan-isp/2022-integrated-system-plan-isp.

Figure 1 The ISP process



2. Multisectoral modelling

Key finding from the AER's transparency review

AEMO must provide further explanations on the relationship between the multi-sectoral modelling and the separately derived:

- *energy efficiency forecasts produced by Strategy Policy Research and consulted on through the 28 April FRG process.*
- *rate of distributed energy resource (DER) uptake (both distributed solar PV and batteries) developed by GEM and CSIRO and consulted on over three FRG events (March to May).*
- *rate of electric vehicle adoption developed by CSIRO and consulted on through the FRG process in February and April.*

AEMO's response

The AER's transparency review identified that stakeholder confusion may exist regarding the interactions of several forecast components that were being concurrently developed and consulted on. One of these was the multisectoral modelling conducted with CSIRO and ClimateWorks Australia.

AEMO applied multisectoral modelling to consider the scale of change that may be expected across the scenarios in response to broader sectoral influences, particularly the role of decarbonisation and the opportunities that would exist for the National Electricity Market (NEM) to provide a low or zero-emission energy source as an alternative to traditional fuels and feedstocks for Australia's economy. The modelling applies a detailed modelling approach to multiple sectors of Australia's economy, with differing levels of granularity for each. The methodology adopted is provided by the CSIRO and ClimateWorks Australia in their published report (multi-sector modelling report)[5].

The AER's review rightly identified a level of interaction that exists between various forecasting components. These components apply detailed methodologies of their own to identify trends affecting each component. As identified in the multisector modelling report (Section 1.8), the detailed forecasts developed for DER and electric vehicle uptake (conducted by CSIRO and Green Energy Markets) were used as inputs to the multisectoral energy modelling.

Economic and demographic forecasts, produced by BIS Oxford Economics for AEMO, were also applied as inputs to the multisectoral energy modelling. This was identified in the multisectoral modelling report (Table 2-4 acknoweldges the impact on residential dwellings, Table 2-6 acknowledges the baselining of industrial activity, and Table 2-7 acknowledges that agricultural activity growth rates are based on the BIS Oxford projections).

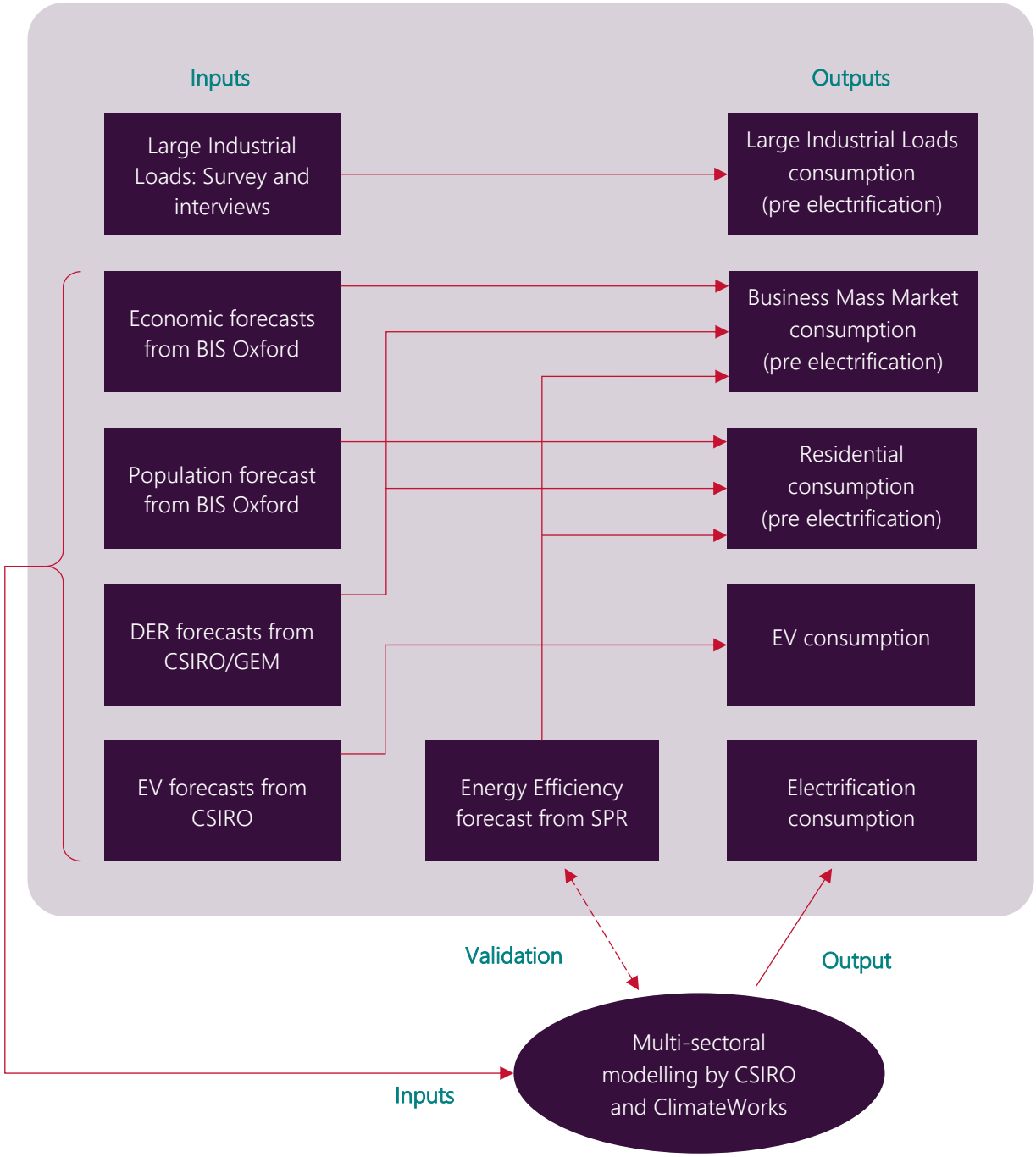
The opportunity for energy efficiency to reduce energy consumption is a key pillar of decarbonisation that is applied within the multisectoral energy modelling. It was also developed independently by Strategy.Policy.Research, and consulted on via the Forecasting Reference Group (FRG). The approach taken

[5] CSIRO and CliamteWorks Australia, Multi-sector energy modelling, 2021, at https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/isp/2021/csiro-multi-sector-modelling.pdf?la=en.

by Strategy.Policy.Research allows fine granularity of the various drivers of energy efficiency investments, including incorporating the impact of various energy efficiency policies identified in the 2021 IASR.

The multisectoral energy modelling's own energy efficiency projections provided a measure of validation to the forecasts provided by Strategy.Policy.Research. AEMO identified appropriate levels of consistency, acknowledging that the model granularity differences would provide some variance in the overall scale of energy efficiency uptake. The magnitude of the forecasts produced by Strategy.Policy.Research and consulted with the FRG were retained following this independent validation. The scale of energy efficiency potential from the multisectoral modelling improved the specific scenario narratives regarding the role of efficiency improvements in the scenarios.

Figure 2 Demand forecast components



3. Distributed energy resources projections

Key finding from the AER's transparency review

AEMO must provide further explanation as to why it proposes to adopt an average of consultant projections for distributed PV and battery uptake for some scenarios and a single source for the remaining scenarios.

AEMO's response

As occurred in 2020, AEMO acknowledged that great uncertainty exists regarding the scale of DER uptake expected in future years and re-engaged two independent consultants for this key input. This approach enables a broader view of drivers and influences for the same scenarios, such that two independent views of future uptake can be understood, by AEMO and stakeholders. The independent consultant forecasts provide a broader outlook of future outcomes, considering that each model has differing levels of importance and influence on the same fundamental inputs and scenario narratives.

AEMO's approach therefore reflects on the appropriate spread of future conditions, as well as the spread with the consultant forecasts, to help determine the mapping of consultant forecasts to the scenarios. AEMO subsequently engaged with the FRG on the appropriateness of the proposed selection choices, with a dedicated session in the FRG on 31 March 2021 for this purpose. This engagement provided an opportunity for AEMO to gather stakeholder feedback on the proposed approach, provide clarity on the differences identified between consultant forecasts, and listen to any alternative suggestions provided by stakeholders.

Slides 12 to 14 of Presentation 1[6] of the 31 March 2021 FRG showed the proposed mapping and logic behind the choice and invited feedback. In summary:

- **Net Zero/Steady Progress**: The choice was to use the average of the two consultants as the central expectation between the two consultants. Averaging forecasts is an accepted method when no alternate reason exists for prioritising one forecast over another[7].
- **Slow Change**: AEMO proposed selecting the consultant forecast that had the highest short-term distributed photovoltaics (PV) uptake, to help inform analysis of future minimum demand forecasts. The CSIRO trajectory for Slow Change (the CSIRO 2021 Slow Growth) was higher before 2030, and was therefore selected to satisfy the intended purpose.
- **Hydrogen Superpower:** AEMO selected GEM's forecast as it had a higher long-term forecast for distributed PV. The scenario focused on stronger electrification to provide a means to decarbonise (as well as new hydrogen opportunities), and with this greater electricity consumption AEMO considered the higher GEM forecast would be reasonably reflective of the distributed investments that would support

[6] AEMO, Draft FRG Minutes, 31 March 2021. Presentation 1, at https://aemo.com.au/-/media/files/stakeholder_consultation/working_groups/other_meetings/frg/2021/frg-meeting-3-pack.zip?la=en.

[7] Chase, C, 2009, Demand-Driven Forecasting: A Structured Approach to Forecasting. John Wiley & Sons, Inc., Hoboken, New Jersey.

these objectives. Greater absorption of distributed PV would be expected with more underlying demand in the grid from new electrified industrial activities.

- **Step Change:** Similar to Hydrogen Superpower, AEMO selected the GEM forecast trajectory as the higher of the two consultant forecasts, and the scenario narrative put greater focus on the consumer-led transition. Applying the upper trajectory for distributed PV and battery storage was considered most appropriate[8]. `

AEMO communicated in the IASR that the application of an averaging approach was most reasonable for the Net Zero 2050 and Steady Progress scenarios as this reflected the consultants best estimates, consistent with the scenario narratives. However applying that same approach to all other scenarios would narrow the range of this key (and uncertain) variable, and AEMO preferred to therefore retain reasonable dispersion for this component.

[8] Note: AEMO presented the mapping of CSIRO Sustainable Growth in the May 2021 FRG which was subsequently revised to using the GEM Sustainable Growth forecast due to the higher PV forecast, relative to Net Zero that was more consistent with the scenario narrative. Given timing constraints before publication this change was not communicated back to stakeholders.

4. Government policy assumptions

Key finding from the AER's transparency review

AEMO must provide further explanation as to why the budgeted policy initiative to develop six renewable zones in Victoria is not sufficiently developed at this stage to determine its impact on the power system and may not be included in the draft ISP, whereas other policy initiatives which are legislated or budgeted will be included in the draft ISP.

AEMO's response

The IASR outlines the Victorian 2020-21 budget initiatives affecting renewable energy zones (REZs) and energy efficiency, which includes $540 million to establish six REZs. While the policy has been considered, the IASR also noted that the level of detail available to AEMO at the time the IASR was published was not sufficient to identify specific impacts on the power system.

Since the publication of the IASR, AEMO has not received the level of detail that would be required for these impacts to be identified. Discussions are ongoing between AEMO and the Victorian Government regarding the development of policy mechanisms that fall under this category.

If the level of detail required to identify specific impacts on the power system is determined and communicated before the Final ISP, leaving enough time for this information to be included in the modelling, AEMO will analyse and clarify specific impacts at that point.

The transparency review noted that "*the IASR states that the 2022 ISP will model other policy initiatives such as the Tasmanian Renewable Energy Target (TRET) on the basis that it has been legislated*". A key difference between TRET and other initiatives, compared to the Victoria's 2020-21 budget initiatives regarding REZs and energy efficiency, is the granularity of information that is visible to AEMO. To consider the impacts in ISP modelling, AEMO requires specific information including:

- The timing and the scope of specific investments that are being funded.
- The technical capabilities of the investments and the capacity of generation that could be expected to be supported by the REZs.
- The specific locations of funded investments (or a sufficiently detailed methodology by which augmentation options are identified, considered, and selected against appropriate criteria), or
- Any other information that may inform the generation and transmission development co-optimisation described in AEMO's *ISP Methodology*.

Once this or similar information is available, AEMO would then appropriately consider the impacts of any funded options, or funding approaches, in the ISP modelling.

5. Forced outage rate projections

Key finding from the AER's transparency review

AEMO must provide further explanation supporting the assumed outage profiles for:

- *OCGT, CCGT, hydro and small peaking plants between 2021 and 2031.*
- *Thermal coal power plant which are assumed to vary over the 10-year projection.*

AEMO's response

AEMO develops forced outage rate projections consistent with its consulted on methodology, as described in the *Electricity Statement of Opportunities*[9] and the *ESOO and Reliability Forecast Methodology*[10]. This methodology predominantly relies on participant-provided information, including the provision of historical outage rate information and, in the case of coal-fired and large gas-fired generators, forward-looking outage rate projections. Participant-provided information is complemented by consultant-derived projections[11] or extrapolation of historical trends in limited circumstances where participant-provided information is not available, or not suitable.

In the case of open-cycle gas turbine (OCGT), combined-cycle gas turbine (CCGT), hydro, and small peaking plants, AEMO's outage projections between 2021 and 2031 are predominantly derived considering the last four yearly historical outage statistics. Because these projections are historically derived, they do not vary over the projection. Where outage projections were provided by large gas-fired generators, the projections provided in 2021 did not exhibit strong trends.

In the case of thermal coal-fired power plants, outage projections between 2021 and 2031 are predominantly sourced from participant-provided projections. Participants consider numerous factors when providing projections, including the age of the plant, maintenance expectations and cycles, and remaining life. In a small number of instances where operators were unable to provide a full set of future projections, AEMO adopted forward-looking outage rates commissioned by AEMO's consultants.

Forced outage rates for coal-fired generators have increased over the last 10 years in all jurisdictions. The projections provided by coal-fired and large gas-fired generator participants remain confidential, and AEMO is not able to reveal the outage information provided by individual participants. However, in aggregate, the participant provided projections show a continuation of the ten year trend towards increasing forced outage rates. This trend also aligns with AEMO's consultant forecast, which notes a potential reason for the trend: "Changing market conditions will encourage some plants to move away from the traditional base load

[9] At https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/nem_esoo/2021/2021-nem-esoo.pdf.

[10] At https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/nem_esoo/2020/esoo-and-reliability-forecast-methodology-document.pdf.

[11] At https://www.aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/inputs-assumptions-methodologies/2020/aep-elical-assessment-of-ageing-coal-fired-generation-reliability.pdf.

operation to load cycling. Such changes to the operating regime will result in a revision to maintenance planning. Planned outages may become more frequent; metal fatigue and creep on high pressure and temperature components will be accelerated; and asset management plans may be required to reflect the need for greater levels of capital and operational expenditure. Depending on the financial returns to the owners, decisions in this regard may have a noticeable impact on a plant's outage rates and reliability."[12]

Key finding from the AER's transparency review

AEMO must explain further the differences, if any, between the two terminologies 'equivalent forced outage rate' and 'effective forced outage rate' are similar or different in definition.

AEMO's response

'Effective forced outage rate' and 'equivalent forced outage rate' have the same meaning and refer to the same calculation in the IASR. In future, AEMO will adopt 'equivalent forced outage rate' in alignment with standard industry terminology.

Feedback from the FRG was taken into account in describing 'high impact, low probability (HILP)' outages in the IASR. This includes renaming HILP outages as 'long duration outages' to provide further clarity as to why these outages are considered and the manner in which they are applied.

[12] At http://www.aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/inputs-assumptions-methodologies/2020/aep-elical-assessment-of-ageing-coal-fired-generation-reliability.pdf.

6. System security assumptions

Key finding from the AER's transparency review

AEMO must provide further explanations of whether any system security assumptions are driven by the minimum demand projections and if relevant, the basis for these assumptions.

AEMO's response

The 2021 IASR does not include any system security assumptions that are driven by minimum demand projections.

The transparency review notes a "*significant downward shift*" in minimum demand projections and states an expectation that AEMO "*outline the implications for maintaining power system security*". AEMO considers that any discussion on the influence of power system limits (for example, how often it binds and what solutions are available to alleviate the limit) will be informed based on the outcome of modelling, rather than being presented as an input or assumption. The approach to modelling power system security services is presented as part of the methodology used in the ISP – see Section 4.2 of the *ISP Methodology*[13].

AEMO agrees that declining minimum demand will affect the ability to operate the power system in a secure operating state. The system security requirements presented in the IASR do not outline the impact of minimum demand because the power system requirements are described independent of demand; that is, the power system requirements (for example, to maintain voltage and frequency) must be met every second of every day, regardless of demand.

The following examples illustrate the delineation between power system requirements and demand projections (which are both considered inputs to the ISP), and their impact on investment and operation (which is an output):

- As demand declines, the power system requirement to maintain a secure voltage profile will remain the constant (for example, to maintain post-contingency voltages below 1.1 p.u.). Although the requirement remains the same, it is reasonably likely that additional investment in reactive plant will become necessary to ensure the requirement can continue to be met. In this example, the demand forecast and the power system requirement are both inputs, and the need for new reactive plant is an output.
- A region requires a minimum number of synchronous generators to remain online to provide fault current so protection can operate and reactive plant can be switched. The requirement to keep those units online itself is independent of minimum demand – it is essential every second of the day. But that requirement will have a greater market impact during periods where demand is low because the generators might otherwise be offline. In this example, the demand forecast and the power system requirements are both inputs, and the market impact is an output.

[13] AEMO. *ISP Methodology*, at https://aemo.com.au/en/consultations/current-and-closed-consultations/isp-methodology.

Appendix 7 in the Draft 2022 ISP[14] discusses the relationship between the ISP and some of AEMO's other planning documents which assess power system security – including challenges relating to minimum demand. This includes:

- **Shortfall management reports** – including Inertia reports, Network Support and Control Ancillary Services (NSCAS) reviews, and System Strength Reports.
- **The Electricity Statement of Opportunities (ESOO)** – which assesses supply, demand and reliability outlook, and is used to inform decisions by market participants, investors and policy makers.
- **The Engineering Framework** – which maps out the changing power system technical needs and the work required to meet those needs, bridging the gap from the current state to ISP future states.

[14] AEMO. *Draft 2022 ISP*, at https://aemo.com.au/energy-systems/major-publications/integrated-system-plan-isp/2022-integrated-system-plan-isp.

7. Capital cost assumptions

Key finding from the AER's transparency review

AEMO must provide further explanations justifying the application of an uplift factor of 50 per cent to the 2018 Entura estimates of capital costs for new entrant pumped hydro generators.

AEMO's response

AEMO uplifted the cost of pumped hydro installations considering stakeholder feedback to the 2020 ISP. This uplift was present in the Draft IASR consultation, and subsequent consultation on the GenCost project. AEMO received submissions to improve the cost estimate for pumped hydro projects in Tasmania from HydroTasmania. This included specific costs on the Cethana project, which were broadly comparable with the values AEMO consulted on (that is, similar to the 50% uplifted costs once regional differences are taken into account). This provided corroborating evidence to AEMO that the uplifted costs were much more appropriate than the originals. GE also provided a response regarding this topic, which was noted in the *IASR Consultation Summary Report*.

AEMO engaged independent experts before releasing the Final 2020 ISP, which incorporated the 50% uplift. That analysis, which was provided on the condition of confidentiality given the intellectual property contained in it, supported the decision to uplift Entura's capital cost estimates, noting that while the cost model appeared appropriate in many places, several components appeared to be missing or underestimated, and there was insufficient transparency in the Entura report to completely validate the estimates.

8. Thermal coal plant assumptions

Key finding from the AER's transparency review

AEMO must provide further explanations justifying the assumption that thermal coal plant will not operate flexibly.

AEMO's response

Modelling coal unit commitment and optimising short term decommitment (that is, turning off a unit in the middle of the day and returning it to service to meet the evening peak) is computationally challenging, and there is no reliable historical data on which to base these assumptions given that no coal generator has displayed this type of behaviour in Australia to date on a consistent basis.

Further, discussions with coal power station operators suggest that this type of behaviour is not considered likely in the future, and that generators are still learning the impacts of this type of behaviour to costs and operations.

Given this uncertainty, it is more prudent to consider other forms of flexibility which are a) observed and b) considered by coal power station operators as likely in the future (for example, operating at minimum load for longer periods, higher ramping relative to history, and extended outages such as a delayed return to service from maintenance, called seasonal mothballing).

AEMO, in individual discussions with participants, has also been informed that if forecast conditions suggest a high amount of ramping and/or extended operation during low prices, participants may consider withdrawing units for a period of days or weeks at a time, as well as more extended outages of some units of the station.

AEMO's approach results in additional flexibility of this kind by informing extended maintenance periods by both wholesale price forecast and participants' public statements. However the extent and type of these forms of response remains highly uncertain, and not able to be reasonably forecast by a pure computational approach.