Integrated System Plan (ISP) Methodology

Issues paper - Standard consultation for the National Electricity Market

Published: 23 October 2024

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New South Wales | Queensland | South Australia | Victoria | Australian Capital Territory | Tasmania | Western Australia

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Explanatory statement and consultation notice

This issues paper commences the consultation which will be conducted by AEMO to review its *ISP Methodology* in accordance with the Australian Energy Regulator's (AER's) *Forecasting Best Practice Guidelines* (FBPG). The FBPG require the *ISP Methodology* to be reviewed at least every four years in accordance with the consultation procedures in Appendix A of the FBPG[1].

The detailed sections of this issues paper include more information on the proposed matters for consultation, including questions seeking particular feedback from stakeholders. AEMO also welcomes feedback from stakeholders on any other aspects of the *ISP Methodology*. Given the consultation topics are at a preliminary stage of development, AEMO is not including a draft or proposed methodology with this issues paper. A draft methodology will be released with the draft report, and will take into account the submissions received in this first stage of consultation. Stakeholders will be given an opportunity to provide feedback on the draft report and draft methodology prior to finalisation of the methodology.

Consultation notice

AEMO invites written submissions from interested persons on the issues identified in this paper to ISP@aemo.com.au by 5:00 pm (Melbourne time) on 22 November 2024.

Before making a submission, please read and take note of AEMO's consultation submission guidelines, which can be found at https://aemo.com.au/consultations. Subject to those guidelines, submissions will be published on AEMO's website.

Please identify any parts of your submission that you wish to remain confidential, and explain why. AEMO may still publish that information if it does not consider it to be confidential, but will consult with you before doing so. Material identified as confidential may be given less weight in the decision-making process than material that is published.

Submissions received after the closing date and time will not be valid, and AEMO is not obliged to consider them. Any late submissions should explain the reason for lateness and the detriment to you if AEMO does not consider your submission.

Interested persons can request a meeting with AEMO to discuss any particularly complex, sensitive or confidential matters relating to the proposal. Please refer to NER 8.9.1(k). Meeting requests must be received by the end of the submission period and include reasons for the request. We will try to accommodate reasonable meeting requests but, where appropriate, we may hold joint meetings with other stakeholders or convene a meeting with a broader industry group. Subject to confidentiality restrictions, AEMO will publish a summary of matters discussed at stakeholder meetings.

[1] At https://www.aer.gov.au/system/files/AER%20-%20Forecasting%20best%20practice%20guidelines%20-%2025%20August%202020.pdf.

Executive summary

Published every two years, AEMO's *Integrated System Plan* (ISP) is a roadmap for the transition of the National Electricity Market (NEM) power system. The ISP is underpinned by an integrated approach to energy market modelling and power system analysis, detailed in the *ISP Methodology*, which is used to identify an optimal development path for the NEM.

In April 2024, Australia's Energy Ministers provided their response to the Federal Government's review of the ISP. While noting that the ISP already "*plays a crucial role in providing consistent projections about where and when investments in new electricity infrastructure will be required to support the energy transformation*", the Energy Ministers also identified a series of actions for the ISP to now provide guidance on additional issues across the energy sector.

AEMO is opening consultation on a review of the *ISP Methodology,* which includes AEMO's proposals for implementing the actions identified by Energy Ministers in response to the review of the ISP.

AEMO will consult with stakeholders to expand ISP consideration of gas market developments

Given the important role identified for gas-powered electricity generation in successive ISPs, AEMO proposes to prepare an expanded gas supply model to better reflect potential gas network, storage and supply opportunities, and to work closely with gas stakeholders to introduce at least one plausible gas development projection for each scenario assessed in the ISP.

AEMO also plans to enhance the *ISP Methodology's* treatment of gas network operational capacity and limitations, including applying constraining daily gas consumption limits, modelling alternative fuel sources, and setting minimum operational capabilities for relevant gas-powered generators.

Analysis of distribution network capabilities and opportunities for consumer energy resources (CER) and other distributed resources

Consumers will play a major role in the future power system, particularly through investment in resources such as rooftop solar, batteries and electric vehicles (EVs). AEMO proposes to include analysis of the opportunities for CER and other distributed resources that may be facilitated by distribution network investments, by introducing representation of distribution network capabilities and opportunities for CER and other distributed resources in the ISP models.

Ultimately these changes are intended to facilitate the provision of more comprehensive information regarding development of CER and distributed resources in the NEM and their role in the power system, as well as to inform distribution network planning.

AEMO proposes to adjust its process regarding actionable projects

As part of the ISP assessment process, AEMO must identify any major electricity transmission projects (or their equivalent) which must to progress as 'actionable'. AEMO considers that for projects which have previously been identified as actionable, it would be more effective to test their benefits at either their proponent's nominated timing, or at a future 'restart timing' representing the time taken to begin development and regulatory processes after a project is paused, rather than testing for all potentially optimal years.

A range of other *ISP Methodology* modelling enhancements are proposed

In this issues paper, AEMO also suggests a range of other enhancements to the *ISP Methodology* to ensure that it remains fit for purpose and incorporates the Energy Ministers' response to the review of the ISP. Some of the proposed changes include:

- enhanced modelling of fixed loads for hydrogen electrolysers,
- changing the modelling of storage devices to consider addressing 'perfect foresight' in the model,
- an updated approach to representing total system strength costs and an updated method for assessing inertia levels, and
- strengthening the representation of candidate renewable energy zones (REZs) to allow consideration of any large dispatchable loads in REZs as well as greater diversity of potential wind resources.

* * *

AEMO is committed to engaging with stakeholders throughout the development of the ISP and welcomes feedback on this review of the *ISP Methodology.* AEMO greatly appreciates the time taken by stakeholders to provide their insights and advice on this important NEM planning process.

Stakeholders are invited to provide a written submission in response to this issues paper. **Submissions should be sent via email to ISP@aemo.com.au and are required to be submitted by 5:00 pm (AEDT) Friday 22 November 2024.** Stakeholder feedback will be used to inform the draft *ISP Methodology* due for release in March 2025. The final *ISP Methodology* will be published in June 2025.

Consultation questions provided in this paper

1. Do you consider that the proposal to develop a gas supply expansion model appropriately addresses the action in the Energy Ministers' response to the Review of the ISP for additional gas analysis to be incorporated in the ISP? If yes, why? If not, why not, and how could this action otherwise be achieved?
2. Do you agree with the proposal for AEMO to develop at least one gas development projection per ISP scenario, and apply the projection as an input to the capacity outlook model? If yes, why? If not, what method would you recommend for the inclusion of gas development projections in the ISP?
3. What alternative approaches should AEMO consider for enhancing the incorporation of gas in the ISP to address the action in the Energy Ministers' response?
4. What improvements could be made to AEMO's proposed approach to increase consideration of gas availability, considering gas transportation and storage capacity?
5. What improvements could be made to AEMO's proposed approach in its capacity outlook models to improve the representation of fuel usage for gas generation, particulary for mid-merit capacity?
6. What are your views on AEMO's proposed inclusion of distribution network capabilities and their impact on CER within the ISP model? What further enhancements could be made?
7. Do you agree with AEMO's proposals to improve its hydrogen electrolyser load modelling, or have further enhancements to suggest? Please provide any supporting evidence.
8. What are your views on AEMO's proposal to test previously-actionable projects for actionability at the project proponent's timing within the actionable window, and at a later re-start timing?
9. Do you agree with AEMO's approach to model storage devices with headroom and footroom energy reserves and imperfect energy targets in the time-sequential modelling component? What improvements should be made to model energy storage limits to better reflect acutal behaviour and address issues of 'perfect foresight'? Please provide any supporting evidence.
10. What risks should AEMO consider when assessing how inverter-based resources (IBR) can complement synchronous machines in providing system strength and inertia?
11. Do you agree with AEMO's approach for uplifting cost and modelling representation for system security services in the ISP? If not, what alternative methods would you recommend? Please provide any supporting evidence.
12. Do you agree with AEMO's proposal to model more than two wind resource quality tranches for geographically large REZs? If not, what alternatives should AEMO consider?

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1. Consultation process

This issues paper commences the consultation which will be conducted by AEMO to review its *ISP Methodology* in accordance with the Australian Energy Regulator's (AER's) *Forecasting Best Practice Guidelines* (FBPG)[2]. The FBPG require the *ISP Methodology* to be reviewed through a two-stage consultation process at least every four years in accordance with the consultation procedures in Appendix A of the FBPG.

The *ISP Methodology* was most recently consulted on through a single-stage process in March 2023, and was originally established through a two-stage process in July 2021.

AEMO's indicative process and timeline for the *ISP Methodology* consultation are outlined in Table 1. Future dates may be adjusted and additional steps may be included if necessary, as the consultation progresses. In the event that these dates change, AEMO will clearly identify the timeline on the webpage for this consultation[3].

Table 1 Consultation steps for *ISP Methodology* process

Step	Timing
Issues paper published	23 October 2024
Written submissions due on issues paper	22 November 2024
Draft report and Draft *ISP Methodology* published	13 March 2025
Written submissions due on draft report and Draft *ISP Methodology*	14 April 2025
Final report and *ISP Methodology* published, to be applied in the 2026 ISP	25 June 2025

In reviewing the *ISP Methodology*, AEMO will address the requirements outlined in the FBPG and Cost Benefit Analysis Guidelines (CBA Guidelines), which include:

- Providing a transparent process.
- Supporting and working with stakeholders in their understanding of AEMO's methodologies.
- Providing additional information to complement the formal documentation.

AEMO notes that the AER is currently consulting on a number of amendments to the CBA Guidelines which will be considered in the *ISP Methodology* development process as they become available.

In this issues paper:

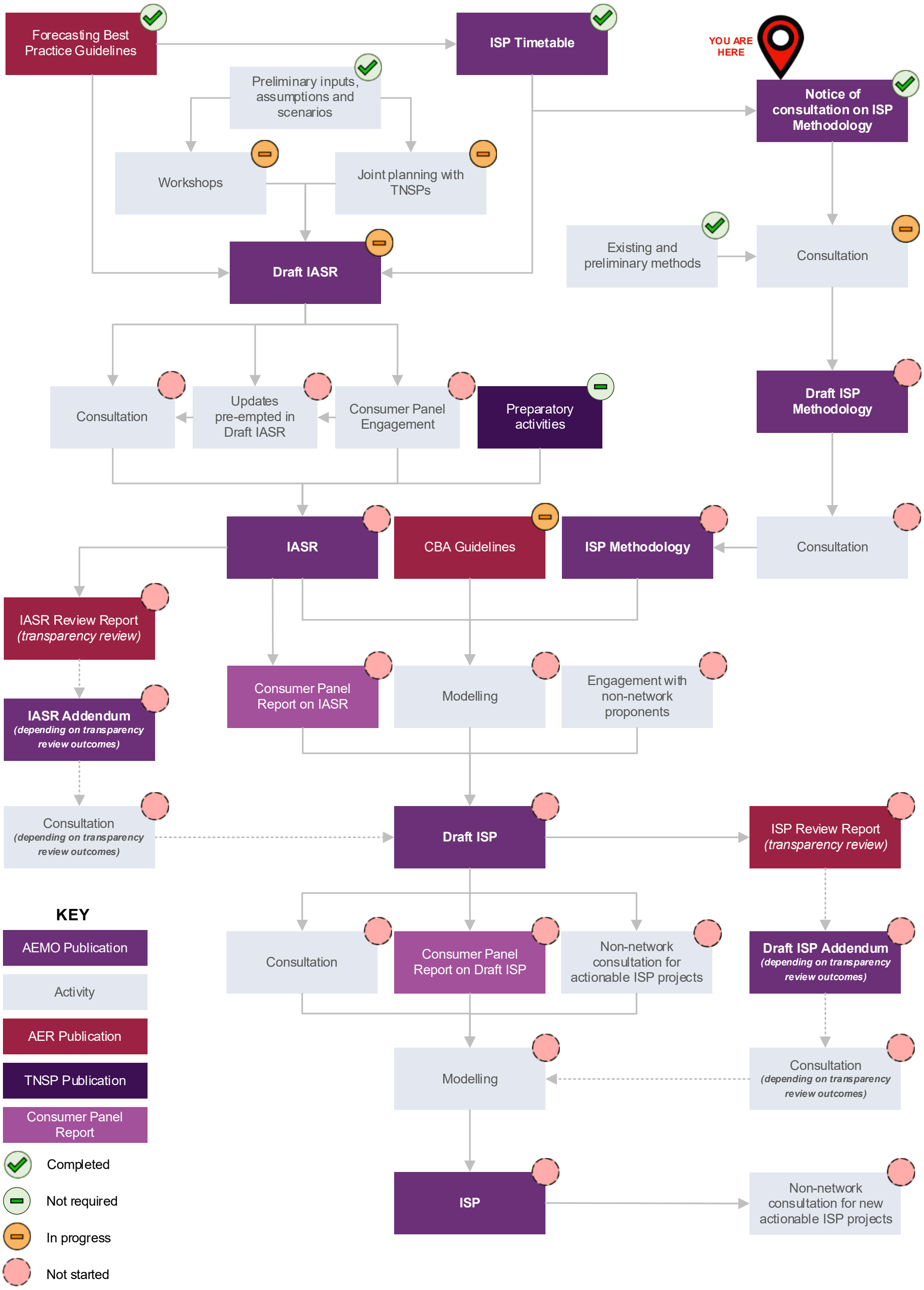
- Section 2 provides background on the review of the *ISP Methodology*.
- Section 3 outlines the existing modelling methodologies.
- Sections 4 to 7 discuss changes being proposed for the amended *ISP Methodology*:
  - Section 4 – Integrating gas in the ISP.
  - Section 5 – Improving demand side modelling.
  - Section 6 – Assessing actionability of transmission projects.
  - Section 7 – Enhancing selected ISP modelling approaches.

[2] AER. Forecasting Best Practice Guidelines. August 2020, at https://www.aer.gov.au/system/files/AER%20-%20Forecasting%20best%20practice%20guidelines%20-%2025%20August%202020.pdf.

[3] At https://aemo.com.au/en/consultations/current-and-closed-consultations/2026-isp-methodology.

The *ISP Methodology* developed for the 2026 ISP may also be used in the 2028 *Integrated System Plan* (ISP) and ISP updates. Figure 1 shows the process to develop the ISP, and current progress on all elements for the 2026 ISP[4].

Figure 1 Navigating the ISP process



[4] The 2026 ISP Timetable provides more information on the key milestones of the 2026 ISP development process, at https://aemo.com.au/energy-systems/major-publications/integrated-system-plan-isp/2026-integrated-system-plan-isp.

2. Background

The *ISP Methodology* was first released in 2021, and was updated in 2023. This current consultation provides an opportunity to ensure that the ISP modelling and cost benefit assessment processes are fit for purpose in the context of the ongoing energy transition. The scope includes implementation of changes needed to deliver on the outcomes of the Australian Energy Ministers' *Response to the Review of the Integrated System Plan*.

In this section:

- Section 2.1 provides context for this consultation.
- Section 2.2 discusses Energy Ministers' response to the review of the ISP.
- Section 2.3 notes matters which are not considered within the scope of this consultation, and why.

2.1. Context for this consultation

Published every two years, AEMO's ISP is a roadmap for the transition of the power system that underpins the National Electricity Market (NEM), with a clear plan for essential infrastructure that will meet future energy needs. The ISP draws on a comprehensive set of inputs, including all relevant federal and state government policies for emissions reduction, and the ISP modelling seeks the optimal mix of generation, storage and network infrastructure investment.

Australia's energy transition has accelerated significantly since the release of the first ISP in 2018, and the first *ISP Methodology* in 2021. Growth in new rooftop solar systems has averaged 12% year on year over the past five years, and these resources contributed more electricity to the grid in the first quarter of 2024 (13%) than did grid-scale solar, wind, hydro or gas. In 2023, large- and small-scale renewables accounted for almost 40% of the total electricity delivered through the NEM, compared to around 30% in 2021.

This consultation provides an opportunity to ensure that the modelling and cost benefit analysis approaches used to prepare the ISP remain fit for purpose, and to incorporate the outcomes of Energy Ministers' response to a review of the ISP undertaken by the Federal Government.

2.2. Energy Ministers' response to the Review of the ISP

Over 2023 and early 2024 the Federal Government undertook a review of the ISP (Review of the ISP), and on 5 April 2024 the Energy and Climate Change Ministerial Council published its *Response to the Review of the Integrated System Plan* (Energy Ministers' response to the Review of the ISP)[5]. The response outlined a series of actions to enable the ISP to set a direction for the energy system as a whole, while maintaining the critical function of the ISP in transmission planning.

The Review of the ISP focused on supporting emissions reduction, integrating gas and electricity planning, enhancing demand considerations, transformation of Australia's energy mix, jurisdictional policy interactions, and the timely delivery of ISP projects.

Not all recommendations from the Review of the ISP will require a change to the *ISP Methodology* to be implemented. Table 2 summarises other AEMO publications which AEMO proposes to amend to implement the actions identified in the Energy Ministers' response to the Review of the ISP. In addition, the Australian Energy

[5] At https://www.energy.gov.au/sites/default/files/2024-04/ecmc-response-to-isp-review.pdf.

Market Commission (AEMC) is deliberating on two rule changes relating to implementation of the Review of the ISP, and the AER will review and if necessary amend relevant guidelines or other supporting instruments to support the rule amendments.

Table 2 Proposed implementation for actions in the Energy Ministers' response to the Review of the ISP

Action in the response to the Review of the ISP	Process for implementation				
	ISP Methodology	2025 *Inputs, Assumptions and Scenarios Report* (IASR)	2025 *Network Expansion Options Report*[A]	*Enhanced Locational Information* report[B]	*Electricity Demand Forecasting Methodology*
Integrating gas into the ISP	✓	✓			✓
Enhanced demand forecasting	✓	✓	✓		✓
Better data on industrial and consumer electrification		✓			✓
Optimising for the demand-side	✓	✓	✓		✓
Coal-fired generation shutdown scenarios	✓				
Improving locational information				✓	
Enhanced analysis of system security	✓	✓			
Jurisdictional policy transparency		✓			
Clarifying policy inclusions		✓			
Improving the accessibility of the ISP[C]					
Incorporating community sentiment		✓	✓		
Additional planning inputs		✓			

A. The *Network Expansion Options Report* is consulted on as part of the IASR. This was previously known as the *Transmission Expansion Options Report*, but has been re-named to reflect the inclusion of both transmission and distribution in future ISPs.
B. The *Enhanced Locational Information* report provides a consolidated set of locational information about where to locate projects in the NEM.
C. AEMO will consider opportunities throughout the ISP development process to enhance consumer understanding of key elements.

2.3. Related consultation processes

This consultation is limited to matters AEMO needs to consider to determine any revisions to the *ISP Methodology*. There is a range of matters relating more generally to the ISP which should be considered through other processes, such as consulation on inputs and assumptions, or consultation on a Draft ISP, rather than through consultation on the *ISP Methodology*. Figure 1 shows consultation opportunities through the ISP development process.

An example of a change that is out of scope of this consultation would be whether AEMO should run a particular new sensitivity analysis. The *ISP Methodology* already broadly outlines how AEMO may conduct sensitivity analysis, and how this analysis is considered in selecting the optimal development path (ODP). However, the specifics of individual sensitivities to be conducted, including parameters to vary and their justification, are considered through other processes including through the consultations on the Draft *Inputs, Assumptions and Scenarios Report* (IASR) and Draft ISP.

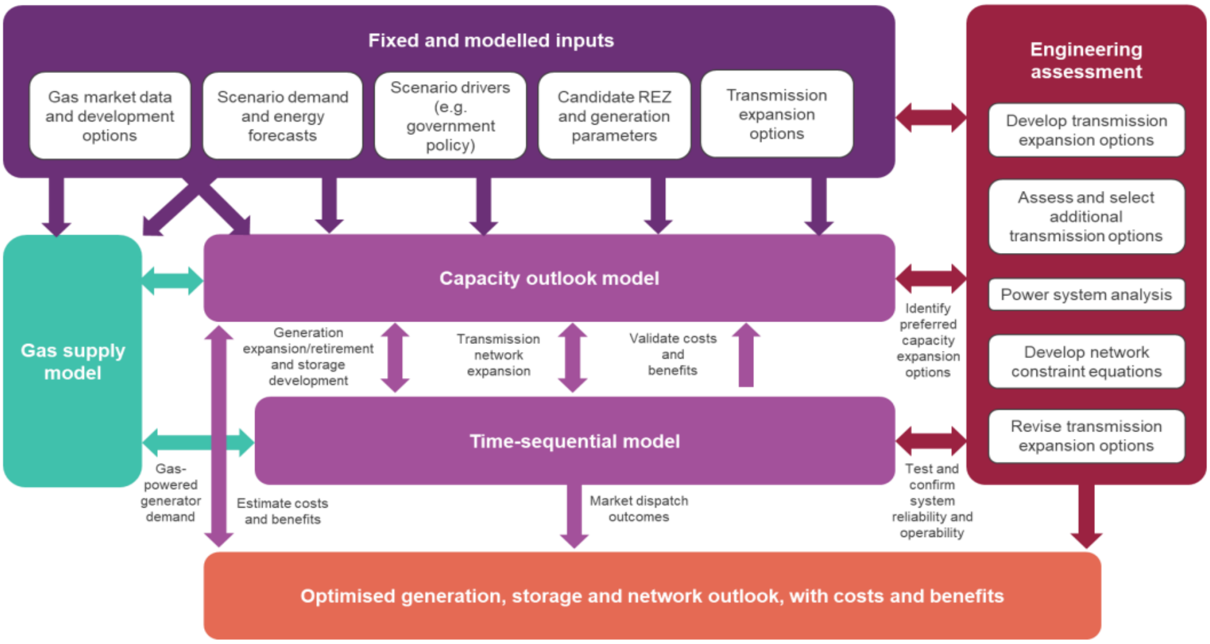
3. Modelling overview

AEMO's current *ISP Methodology* sets out the methodologies for the:

- **Modelling applied in the ISP.** This includes the capacity outlook model, time-sequential model, gas supply model and engineering assessments.
- **Cost-benefit analysis used in the ISP.** This includes:
  - AEMO's approach to applying the steps outlined in the AER's CBA Guidelines.
  - Differentiating scenarios and sensitivities and their treatment in informing the ODP.
  - Outlining how AEMO determines weights for scenarios.

Figure 2 shows the current ISP modelling methodology, noting that the combination of the processes described above leads to the determination of the ODP for an ISP. The preparation of fixed and modelled inputs is not consulted as part of the *ISP Methodology*. Instead, these are covered extensively in AEMO's IASR consultation processes and the *Electricity Demand Forecasting Methodology*.

Figure 2 Overview of the current ISP modelling methodology



This section explains the components of the current *ISP Methodology,* and notes which of the components would be affected by the changes proposed in this issues paper.

- Section 3.1 – Capacity outlook model.
- Section 3.2 – Time-sequential model.
- Section 3.3 – Gas supply model.
- Section 3.4 – Engineering assessment.
- Section 3.5 – Cost-benefit analysis.
- Section 3.6 – Changes proposed across methodology components.

3.1. Capacity outlook model

Capacity outlook modelling is used to determine the most cost-efficient long-term trajectory for electricity generation, storage, hydrogen electrolysers and network investments and retirements.

For the ISP, AEMO uses a suite of capacity outlook models which make various simplifications depending on the particular purpose of each model. The primary trade-off when making simplifications, which are required to keep the modelling computationally feasible, is between model granularity (spatial and temporal) and the modelling horizon.

AEMO proposes to continue to use the following variants of the capacity outlook model:

- Single-Stage Long-Term Model (SSLT) – the SSLT optimises the entire modelling horizon in a single stage, to allow consideration of aspects with long-term impacts, such as:
  - Emissions budgets across the entire modelling horizon.
  - Development of new high-utilisation fossil-fuelled generation (where appropriate).
  - Generator retirements.
  - Preliminary co-optimisation of generation and transmission developments at low granularity to enable identification of potential development paths for further examination in subsequent modelling phases.
- Detailed Long-Term model (DLT) – the DLT divides the modelling horizon into multiple steps which are optimised separately and sequentially. The DLT provides a higher granularity representation of each day's demand and variable renewable energy (VRE) availability while leveraging off the outcomes of the SSLT such as the decomposed carbon budget, retirement decisions, and development of high-utilisation fossil-fuelled generation. The DLT is primarily used to:
  - Optimise the development, location, and operation of VRE, storage (battery and pumped hydro), electrolysers, and other generation such as flexible gas generators.
  - Evaluate the transmission development paths[6] that are tested individually. Testing of the network development paths, including identification of generation and storage developments that would be optimal for each development path, is a key process in determining the ODP and performing cost-benefit analysis.

Table 3 in Section 3.6 below shows where changes that are proposed in this issues paper would affect the capacity outlook model.

3.2. Time-sequential model

The time-sequential model optimises electricity dispatch for every hourly or half-hourly interval while considering various power system limitations, generator forced outages, variable generation's availability, and (optionally) bidding models. This model validates the outcomes of the capacity outlook model and feeds information back into it.

The time-sequential modelling used in the ISP has numerous purposes and requires a number of alternative configurations which are targeted at best meeting each purpose. Compared to the capacity outlook modelling,

[6] Development paths refer to combinations of transmission and non-network augmentations.

the time-sequential modelling requires AEMO to overlay strictly technical assumptions with views on portfolio dynamics and strategic decisions.

AEMO applies detailed analytics to inform these considerations and provide insights on the future operability and security of the system. There are limitations, however, to the extent to which these behaviour drivers can be accurately forecast and reflected in the modelling, given the dynamic nature of operational decisions applied by generation portfolios.

The time-sequential model is used to provide insights on:

- Possible exceedance of the reliability standard and the Interim Reliability Measure.
- Potential economic drivers of generator retirements.
- The feasibility of the generation and transmission outlook when operating conditions and more detailed intraregional network limitations are modelled.
- An indication of where possible congestion points may exist and how network augmentations would be beneficial in alleviating network issues.
- A more accurate forecast of the annual generation dispatch and fuel offtake.
- Impacts of weather variability on dispatch outcomes.
- Impacts of unplanned generation outages.
- The number of synchronous generators online.
- Assessment of system strength, inertia, and plant ramping characteristics.

Table 3 in Section 3.6 below shows where changes that are proposed in this issues paper would affect the time-sequential model.

3.3. Gas supply model

The gas supply model simulates daily gas supply and demand balances over a 20-year timeframe. The model computes energy balances at all levels of a gas system from reservoirs, basins or liquefied natural gas (LNG) facilities to the demand centres, in each gas network node and time period, and supplies gas at minimum total system cost subject to the infrastructure's technical capabilities.

AEMO uses the gas suppy model to prepare its *Gas Statement of Opportunities* (GSOO). The model may also be deployed in the ISP to validate the assumptions affecting GPG developments regarding the adequacy of gas pipeline and field developments, by using the outcomes of the capacity-outlook and time-sequential models. Insights from the gas supply model may then be provided back to the capacity outlook and time-sequential models to improve the overall electricity investments identified in the ISP.

More information on the detailed gas supply and demand methodologies is available in AEMO's GSOO publication materials[7].

Table 3 in Section 3.6 below shows where changes that are proposed in this issues paper would affect the gas supply model.

[7] At https://aemo.com.au/energy-systems/gas/gas-forecasting-and-planning/gas-statement-of-opportunities-gsoo.

3.4. Engineering assessment

The engineering assessment examines and investigates possible engineering and operational solutions to emerging transmission network limitations identified by the capacity outlook model and time-sequential model. There are four main components to the engineering analysis:

- Development of transmission and non-network options for use as inter-regional, inter-sub-regional and renewable energy zones (REZs) network expansion.
- Assessment and selection of candidate options to be used in the capacity outlook model.
- Power system analysis such as thermal capability, voltage stability and system security assessments to account for power system requirements.
- Consideration of the cost of transmission to ensure the cost estimates for network expansion are as accurate as possible.

Table 3 in Section 3.6 below shows where changes that are proposed in this issues paper would affect the engineering assessment.

3.5. Cost-benefit analysis

The cost-benefit analysis (CBA) is the approach that AEMO uses to develop and test alternative development paths (DPs), and ultimately determine the ODP. Many different DPs are considered, each consisting of a different set of network projects and timings tested in the DLT capacity outlook model across scenarios. The DPs are then evaluated in terms of net market benefits – that is, the difference in discounted total system cost between a DP and the 'counterfactual' for each scenario.

The counterfactual is a DP that has no new major transmission network augmentation developments, but still meets power system reliability and security needs while providing a path to net zero. The counterfactual for each scenario utilises the existing electricity transmission system and may include other infrastructure investments such as gas generation with carbon capture and storage, new energy storage development, and renewable energy. The parameters and costs for these alternative infrastructure investments are applied consistent with consultation undertaken on inputs and assumptions to be applied in the ISP through the IASR process.

AEMO must at a minimum use a scenario-weighted approach to rank the DPs against each other. AEMO may also consider potential over- or under-investment regrets, sensitivity analysis to consider risks and benefits associated with alternative input assumptions that are uncertain, and consumer risk preferences, to inform the selection of the ODP.

There are six steps to the CBA process for selecting the ODP in the ISP:

1. Determine the least-cost DP for each scenario; that is, the DP that delivers the lowest total system cost and maximises net market benefits.
2. Build candidate development paths (CDPs), which refers to a collection of DPs that share a set of potentially actionable ISP projects across scenarios.
3. Assess each CDP across all scenarios through further simulation of DPs.
4. Evaluate net market benefits for the DPs in each scenario that comprise each CDP.

5. Rank the CDPs using both a scenario-weighted approach, where the weighted average net market benefits are calculated for each CDP based on the likelihood of each scenario, and potentially also a worst weighted regrets approach, where the maximum weighted regret (difference in net market benefits between a given CDP and the least-cost DP for that scenario) across scenarios is calculated for each CDP.
6. Finalise the selection of the ODP, with consideration for the rankings from the previous step, as well as more robust sensitivity analysis on the CDP collection and through any other applications of AEMO's professional judgement provided the choice is explained fully and reasonably reflects consumers' level of risk neutrality or aversion.

Table 3 in Section 3.6 below shows where changes that are proposed in this issues paper would affect the cost benefit analysis.

3.6. Changes proposed across methodology components

Table 3 Map of changes proposed in this paper against methodology components affected

Proposed change	Reference	Capacity outlook model	Time-sequential model	Gas supply model	Engineering assessment	Cost-benefit analysis
Expand gas supply model and introduce gas development projections in the ISP	Section 4	✓	✓	✓		
Develop an approach to analyse distribution network capabilities and opportunities for CER and other distributed resources	Section 5.1	✓	✓		✓	✓
Lay out a method for separately modelling hydrogen electrolyser loads	Section 5.2	✓	✓			
Test for actionability at project proponents' timing	Section 6.1	✓				✓
Consider REZ benefits more closely by changing the process for take-one-out-at-a-time (TOOT) analysis	Section 6.2	✓			✓	✓
Address perfect foresight for storage devices in the time-sequential model	Section 7.1	✓	✓			
Enhance analysis of power system security	Section 7.2	✓	✓		✓	✓
Add flexibility to model candidate REZs with large dispatchable loads	Section 7.3	✓	✓		✓	
Add flexibility to better represent the diversity of potential wind resources within large candidate REZs	Section 7.4	✓	✓		✓	

4. Integrating gas in the ISP

In their response to the Review of the ISP, Energy Ministers endorsed the recommendation that AEMO expand its consideration of gas market conditions in the ISP (see: Breakout box 1). This recommendation would require AEMO to incorporate additional analysis and gas sector data as well as 'development projections' for the sector, including hydrogen and biomethane.

In this section, AEMO proposes a method for expanding the gas supply model and introducing gas development projections in the ISP.

Breakout box 1 – Action in the Energy Ministers' response to the Review of the ISP– Integrating gas into the ISP

AEMO should expand its consideration of gas market conditions in the 2026 ISP. This should include but not be limited to:

- *Carrying out additional analysis of future gas demand and gas pricing.*
- *Developing projections about the future utilisation of gas infrastructure.*
- *Collating information about dates of expected gas pipeline or [gas-powered generation] closure or conversion, such as from natural gas to hydrogen.*
- *Updating medium- and long-term projections of gas generator fuel costs, including hydrogen and biomethane, to reflect expectations about gas market developments.*
- *Providing more information in the ISP about how ISP modelling scenarios are integrated in its gas supply model.*

Working closely with stakeholders and drawing on the deeper understanding of future gas market conditions, AEMO should include 'development projections' in the 2026 ISP for the gas sector and:

- *Use this capability to identify and iteratively analyse the gas sector project trade-offs with electricity development needs, with the sole aim of optimising electricity infrastructure investments in the ISP.*
- *Update the development projections to reflect the outcomes of this analysis.*
- *Publish the updated development projections in the ISP.*

The development projections should set out AEMO's projections on how it expects the gas sector, including hydrogen and biomethane, to develop (both in terms of demand, and infrastructure investment to supply expected demand) under prevailing policies and market incentives.

Existing approach

AEMO's gas supply model evaluates the reserves, production, and transportation capacity of Australia's East Coast Gas System to calculate the delivery of gas supply to gas consumers. This model is used to consider:

- *adequacy of existing, committed and anticipated gas projects and infrastructure to meet the future gas needs of consumers.* This is included in AEMO's GSOO, and may also be used to prepare gas infrastructure limitations applied in the ISP capacity outlook models; and

- *capability of the East Coast Gas System to deliver gas for electricity generation purposes*. This is implemented within the capacity outlook model for the ISP, as constraints on gas generators whose operations may be impacted by gas network congestion.

In the 2024 ISP, AEMO enhanced its considerations of the existing gas infrastructure capacity limitation on gas-powered generators (GPG) for the capacity outlook model, within the procedure already included in the *ISP Methodology*. AEMO incorporated a daily gas consumption constraint to the southern regions of the NEM to reflect the historical availability of gas for electricity generation purposes. An additional constraint represented the use and cost of on-site secondary fuels, and its storage. The results of this enhancement are available in the Appendix 2 of the 2024 ISP[8].

Proposed approach

Development of a gas supply expansion model

To address actions in the Energy Ministers' response to the Review of the ISP on expanding gas considerations in the ISP, AEMO proposes to develop and apply a gas supply expansion model, which incorporates gas expansion for pipeline, gas storage, and/or production augmentations, informed by industry engagement on likely or plausible augmentations in the gas sector. The inclusion of gas system expansion capabilities will enable greater consideration in the ISP of how gas investments may impact on electricity investments relevant to meeting electricity power system needs.

AEMO proposes to add an additional expansion module to the existing gas supply model, to be used for identifying potential solutions to gas supply shortfalls. This gas supply expansion model would test a suite of potential gas development options informed by industry engagement to determine where supply and infrastructure options or augmentations could be located to meet ISP development pathways under different scenarios and to maintain appropriate adequacy of gas supplies in the East Coast Gas System.

AEMO envisions the gas supply expansion model will be used to:

- Consider cost-efficient gas supply and transportation expansion options identified through gas industry stakeholder engagement to meet forecast gas consumption for electricity generation from the time-sequential model.
- Establish gas development projections[9] based on optimised outputs. This would include at least one projection per ISP scenario.

Data on plausible supply and infrastructure options

Through industry consultation, AEMO intends to develop plausible gas supply and augmentation options for inclusion in the gas supply expansion model, that consider both natural gas and renewable gas options (such as biomethane and hydrogen). AEMO proposes that stakeholder engagement and information collection will be implemented through existing GSOO surveys, open submissions for gas development projects, or direct discussion with gas industry stakeholders.

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[8] At https://aemo.com.au/en/energy-systems/major-publications/integrated-system-plan-isp/2024-integrated-system-plan-isp.

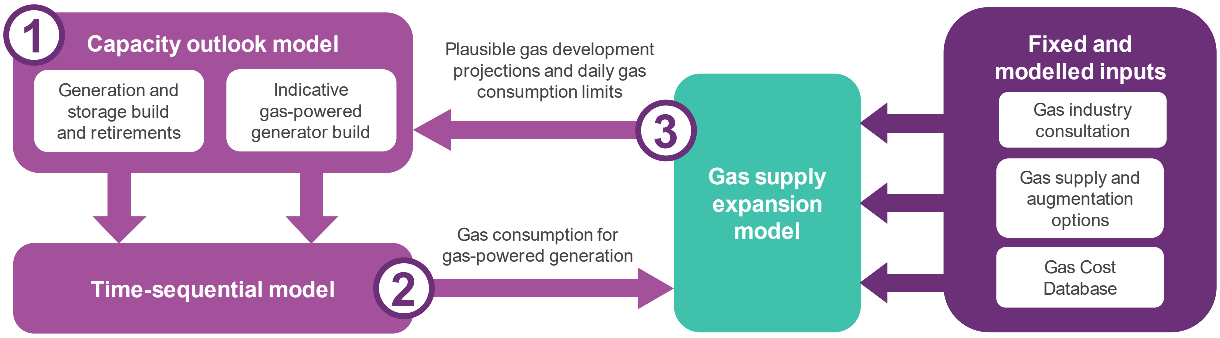
[9] 'Gas development projections' refers to projections of developments in the covered gas industry used by AEMO in the development of an ISP. It is assumed that these will be combinations of supply, transportation and storage options that provide for gas supply adequacy under different scenarios. The AEMC is currently consulting on a definition of 'gas development projections' as part of the *Better integrating gas and community sentiment into the ISP* rule change, and AEMO will prepare its *ISP Methodology* in accordance with the definition in the final rule.

It is anticipated that some generic expansion solutions will be developed as part of the IASR process. As part of this process, AEMO will develop a database of infrastructure costs for new natural gas, biomethane and hydrogen projects, similar to AEMO's Transmission Cost Database[10] for electricity transmission infrastructure, for use as an input to the gas supply expansion model. The purpose of the cost database is not to assist in identifying an 'optimal' gas supply solution, but to develop a plausible gas development projection for each scenario through consideration of investment trade-offs that might exist between gas and electricity sector investments.

Interaction with the capacity outlook and time-sequential models

Figure 3 illustrates the proposed interaction between the gas and electricity models.

Figure 3 Interaction between the electricity and gas supply expansion models



It has the following steps:

1. An initial simulation from the capacity outlook model (either unconstrained or using historical availability in terms of limitations to the daily gas supply capacity to GPG) would inform the time-sequential model in terms of GPG developments to forecast the gas consumption.
2. The gas supply expansion model would then take the projected gas consumption from the time-sequential model as an input, and iteratively analyse gas supply and pipeline augmentations based on a suite of options. AEMO is also exploring how the model could assess hydrogen and biomethane developments to meet forecast demand for renewable gases.
3. Outputs from the gas supply expansion model would inform a set of potential gas development projections. These projections would be taken as an input by the capacity outlook model. For example, these development projections may impact the daily gas generation available across the NEM, influencing the electricity investments for firm capacity (including GPG and electricity storage devices, for example).
4. AEMO proposes to complete the process above at least once for each scenario to facilitate greater consideration of gas sector capabilities and influence on electricity investments.

AEMO proposes that when assessing the ODP and the benefits of electricity transmission, it will only include costs and benefits in the CBA which are within the scope of the electricity sector. That is, while gas sector costs

[10] AEMO's Transmission Cost Database (and associated user manual and explanatory report) is at https://aemo.com.au/en/energy-systems/major-publications/integrated-system-plan-isp/2024-integrated-system-plan-isp/current-inputs-assumptions-and-scenarios/transmission-cost-database.

would be included in the gas supply expansion modelling in determining plausible gas development projections, they would not be considered through the ISP cost benefit analysis process[11].

The gas supply expansion model will not be a co-optimisation of gas and electricity developments. As per the actions in the Energy Ministers' response to the Review of the ISP, the gas development projections should be used to "*identify and iteratively analyse the gas sector project trade-offs with electricity development needs, with the sole aim of optimising electricity infrastructure investments in the ISP*". The intention is to provide the ISP development paths with a guide to a plausible gas development projection for each scenario that takes into account realistic gas supply limitations and provides some indication of the impact on the cost of supply.

Application of gas development projections in the ISP

AEMO proposes to include the gas development projections in the capacity outlook model to inform electricity investments in generation, (electrical) storage and network developments. At least one plausible gas development projection will be developed per scenario to inform the assessment of electricity investment, and AEMO intends to consult with gas industry stakeholders to support the development of these projections, up to and including the Draft ISP.

These gas development projections may also influence the operability of gas generators, with more explicit consideration of the daily gas that will be available from gas production, transportation and gas storage facilities. This will extend the consideration applied in the 2024 ISP to apply daily gas consumption limits to gas generators connected in southern regions of the East Coast Gas System, informed by the most recent GSOO analysis. Where secondary fuels are appropriate (for example diesel or hydrogen), the approach will also consider the cost and operational impact of on-site secondary fuel storage to be considered. In assessing the needs of the gas system, AEMO has considered it important to capture the level of gas usage consistent with outcomes observed in the East Coast GasSystem. That is, if the capacity outlook models do not reflect similar consumption levels to those observed in the market, due to the cost-reflective approach to dispatching generation technologies, then AEMO may adapt the operation of mid-merit gas generators in the capacity outlook model to improve alignment between modelled and actual outcomes.

AEMO is considering the option of also developing an additional gas development projection for the counterfactual of each scenario. This would reflect a future where the gas sector invests in gas developments, compensating for the lack of investment in new major electricity transmission augmentations (other than committed and anticipated projects). However, AEMO is not proposing to include the costs or benefits from any gas development paths in the ODP selection process. This is consistent with the approach taken in the 2024 ISP, and with the Energy Ministers' Response to the Review of the ISP, which specifies the ISP must continue to have "*the sole aim of optimising electricity infrastructure investments*".

[11] This approach is consistent with the requirement in the AER's Cost Benefit Analysis Guidelines that in estimating classes of costs under the ISP analysis only costs that can be measured as a cost to generators, distribution network service providers (DNSPs), TNSPs and consumers of electricity can be included. It is also consistent with the definition of *net economic benefit* in the National Electricity Rules.

Consultation questions

1. Do you consider that the proposal to develop a gas supply expansion model appropriately addresses the action in the Energy Ministers' response to the Review of the ISP for additional gas analysis to be incorporated in the ISP? If yes, why? If not, why not, and how could this action otherwise be achieved?
2. Do you agree with the proposal for AEMO to develop at least one gas development projection per ISP scenario, and apply the projection as an input to the capacity outlook model? If yes, why? If not, what method would you recommend for the inclusion of gas development projections in the ISP?
3. What alternative approaches should AEMO consider for enhancing the incorporation of gas in the ISP to address the action in the Energy Ministers' response?
4. What improvements could be made to AEMO's proposed approach to increase consideration of gas availability, considering gas transportation and storage capacity?
5. What improvements could be made to AEMO's proposed approach in its capacity outlook models to improve the representation of fuel usage for gas generation, particulary for mid-merit capacity?

5. Improving demand side modelling

In their response to the Review of the ISP, Energy Ministers requested an action for AEMO to enhance demand forecasting in the ISP to improve the consideration of electrification, and of accessing the benefits of CER and distributed resources (see: Breakout box 2). In particular, Energy Ministers requested analysis on how distribution network investments, programs and plans may impact CER and distributed resources development, as well as inclusion of these findings in the ISP.

AEMO notes that these changes may also require subsequent adjustments to AEMO's forecasts for underlying and operational demand as they are applied in the ISP. AEMO is separately consulting on its wider forecasting methodology in its 2024 *Electricity Demand Forecasting Methodology* consultation[12]. That consultation will take into account implications of the demand-side modelling outcomes considered in this section, and broader forecasting enhancements including those identified in the ISP Review.

In this section:

- Section 5.1 develops an approach to include analysis of distribution network capabilities and opportunities for CER and other distributed resources in the ISP model.
- Section 5.2 lays out a method for separately modelling hydrogen electrolyser loads.

Breakout box 2 – Actions in the Energy Ministers' response to the Review of the ISP – Enhanced demand forecasting, and optimising for the demand side

AEMO should enhance demand forecasting in the 2026 ISP by:

- *Undertaking targeted stakeholder engagement to enhance assumptions underpinning CER and distributed resources projections in the ISP. The assumptions should reflect a comprehensive view of initiatives affecting CER and distributed resources uptake and evaluate the implications for operational demand.*
- *Analysing how electrification and CER/distributed resources development sensitivities affect operational demand projections and consider these directly in the ISP modelling where relevant.*
- *Subject to available information, analysing how DNSP investments, programs and annual plans, may impact CER and distributed resources development, and thereby the ODP for transmission, and include these findings in the ISP in order to send clearer signals to inform DNSP planning.*
- *Developing a framework, methodology and guidance material to support DNSPs and jurisdicitons to develop projections and undertake analysis in a consistent manner to support the ISP's development.*
- *Including a statement in the 2026 ISP, and subsequent ISPs, aimed at informing the market and policy makers about the expected development of CER and distributed resources. The statement should be sufficiently detailed to provide a baseline for the identification of opportunities to promote the uptake of CER and distributed resources within each jurisdiction.*

The System Planning Working Group [convened by the Federal Government] and AEMO will work with the relevant stakeholders, including DNSPs, to develop a suitable approach to trade off the cost of unlocking increasing tranches of orchestrated CER and distributed resources against other investment options for use in the earliest ISP practicable.

[12] See https://aemo.com.au/consultations/current-and-closed-consultations/2024-electricity-demand-forecasting-methodology-consultation.

5.1. Analysing distribution network capabilities and opportunities for CER and other distributed resources

Existing approach

In the current *ISP Methodology*, CER forecasts are applied as inputs to the ISP model, without further analysis of the underlying distribution network capabilities and opportunities for CER and other distributed resources. This means that in the capacity outlook modelling, the ISP currently assumes that rooftop solar and other distributed solar can operate consistent with the solar resources that are forecast to occur, and that distribution networks will be sufficiently expanded to facilitate the forecast in each scenario.

AEMO considers CER to be of critical importance to the energy transition. In the 2024 ISP, the forecast four-fold increase in rooftop solar capacity (and other distributed solar) formed a substantive component of total new installed capacity by 2050, with rooftop and other distributed solar making up 86 gigawatts (GW) of total installed capacity in the *Step Change* scenario, while utility-scale wind and solar made up 127 GW of installed capacity. By investing in CER, households and businesses are playing a transformative role in the future energy system, and will need to be supported by distribution networks, coordination systems and markets.

The Energy Ministers' response to the Review of the ISP called for AEMO to consider the role of distribution network capabilities and opportunities to support CER and other distributed resources in the future energy system. This is to include consideration of investment plans and costs to access opportunities beyond existing distribution network capabilities.

Proposed approach

The Energy Ministers' response to the Review of the ISP requested that AEMO analyse how distribution network service provider (DNSP) investments, programs and annual plans may impact CER and distributed resources development, and therefore the ODP of the ISP. These findings are to be included in the ISP to send clearer signals to inform distribution network planning, and to communicate to the market and policy-makers about the expected development of CER and distributed resources.

AEMO will engage extensively with DNSPs to understand existing and future distribution network capabilities and opportunities for incorporating CER and other distributed resources. This will include the existing distribution network capabilities as they relate to the operation of CER such as rooftop solar and batteries – that is, understanding how network capabilities may impact CER operation with respect to exporting generation, as well as charging and discharging where relevant. The representation of these capabilities will be informed by inputs from the DNSPs, to be gathered and consulted on through AEMO's *Network Expansion Options Report*[13], which will also include cost curves for potential distribution network augmentations associated with accommodating higher levels of CER operation. AEMO expects that this data will necessarily evolve and improve over successive ISPs.

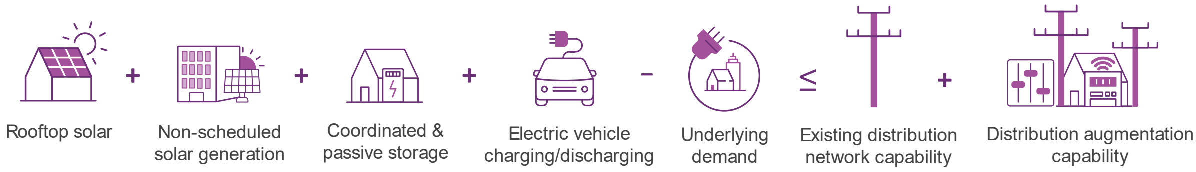
AEMO proposes to implement distribution capabilities and augmentations in the ISP models at the sub-regional level, meaning that data relating to distribution capabilities and augmentations will need to be aggregated and summarised – the ISP model is not sufficiently granular to allow representation of full detail of the distribution networks. This proposed approach should allow the ISP models to identify opportunities for distribution network augmentations to facilitate increased operation from CER and other distributed resources, subject to the nature

[13] Previously known as the *Transmission Cost Report* and the *Transmission Expansion Options Report*, and prepared as part of the IASR consultation process.

of the data that can be made available. By inclusion in the capacity oulook model, existing capabilities and augmentation opportunities may be compared with utility-scale generation and storage options, and transmission network investment options.

AEMO's current assessment is that it is appropriate to apply this approach for consideration of distribution network investment impacts on CER and distributed resources. AEMO intends to model distribution network capabilities and opportunities for CER and other distributed resources as outlined in Figure 4 below, and the following equation.

Figure 4 Representation of distribution network capabilities and opportunities for CER and other distributed resources, to be applied for each sub-region in the ISP model



Note: Other distributed resources may also be included in the left-hand side of this equation.

$$Gen_{PV} + Gen_{NSG} + (Discharge_{Coord\ st.} - Charge_{Coord\ st.}) + (Discharge_{Passive\ st.} - Charge_{Passive\ st.}) + (Discharge_{Passive\ EV} - Charge_{Passive\ EV}) + (Discharge_{V2G} - Charge_{V2G}) - Underlying\ demand \leq Distribution\ Existing\ Capability + Distribution\ Augmentation\ Capability$$

where:

- Gen_{PV} and Gen_{NSG} represents generation from rooftop solar and non-scheduled generation.
- $Discharge_{Coord\ st.}$, $Discharge_{Passive\ st.}$, $Discharge_{Passive\ EV}$ and $Discharge_{V2G}$ represent the discharge of CER storages (both residential and commercial sized non-scheduled storage) and EVs associated with a subregion.
- $Charge_{Coord\ st.}$, $Charge_{Passive\ st.}$, $Charge_{Passive\ EV}$ and $Charge_{V2G}$ represent the charging of CER storages and EVs associated with a subregion.
- $Underlying\ demand$ represents a modelling trace for underlying demand.
- $Distribution\ Existing\ Capability$ reflects the existing ability for the distribution network to support CER for each sub-region.
- $Distribution\ Augmentation\ Capability$ reflects the increase on the distribution network capability to support CER for each sub-region, as a result of distribution augmentation developments. Indicative cost curves for distribution augmentation to facilitate CER will be developed and presented in the *Network Expansion Options Report*.

Consultation questions

6. What are your views on AEMO's proposed inclusion of distribution network capabilities and their impact on CER within the ISP model? What further enhancements could be made?

5.2. Improving hydrogen electrolyser load modelling

Existing approach

For scenarios that feature demand growth for hydrogen, including that which is used for green steel production, the capacity outlook model is used to determine optimal electrolyser expansion and operation to meet that demand, subject to the assumed operational flexibility of electrolysers and the cost of developing and operating these assets. This includes therefore the influence that electrolyser operation has on the investment requirements in generation, storage and transmission development that minimises total system costs.

AEMO currently models the fixed and flexible load components for hydrogen produced for domestic use, export ammonia, and for use in green steel production. The fixed load component is modelled as a specific percentage of the installed electrolyser capacity and the flexible component is given as a monthly energy target for the electrolysers.

Another fixed load that is a function of the annual hydrogen demand for export and green steel making is modelled to represent the required fixed electricity demand to convert hydrogen to ammonia for easier transport, and for electric arc furnace demand involved in steel making. Up to and including the 2024 ISP, these fixed load components for domestic and export use for hydrogen and green steel were bundled together.

Domestic hydrogen demand is specified for each sub-region, but the hydrogen demand for export and for green steel manufacturing is provided as a NEM-wide target. The allocation of electrolyser capacities among the sub-regions in the NEM are determined by the capacity outlook models.

Proposed approach

AEMO proposes to make the following changes to modelling hydrogen in the capacity outlook models:

- Explicitly disaggregate hydrogen demand for green commodity production (such as steel) from hydrogen demand for export, providing greater clarity and transparency in the model outputs.
- Applying minimum utilisation factors developed and consulted in the IASR to represent electrolyser operation that meets economic investment requirements.
- Consider adjusting the timeframe of production requirements from monthly to a daily basis to reflect stakeholder feedback received during the consultation on the 2024 ISP, to improve consideration of hydrogen storage needs.

These changes to hydrogen modelling would allow AEMO to provide further detail and unbundle the drivers for meeting different hydrogen requirements over the modelling horizon.

Consultation questions

7. Do you agree with AEMO's proposals to improve its hydrogen electrolyser load modelling, or have further enhancements to suggest? Please provide any supporting evidence.

6. Assessing actionability of transmission projects

AEMO has identified several potential adjustments to the processes used to consider actionability of transmission projects in the ISP.

In this section:

- Section 6.1 proposes that AEMO align with project proponent timings for projects which have previously been identified as actionable, when re-considering actionability in future ISPs.
- Section 6.2 proposes closer consideration of REZ benefits by changing the process for take-one-out-at-a-time (TOOT) analysis.

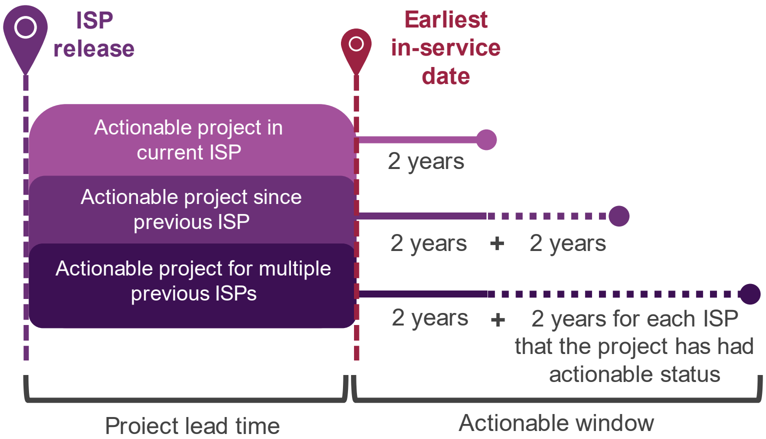
6.1. Testing for actionability at project proponents' timing

Existing approach

In the current *ISP Methodology*, an actionable window is set such that cost-benefit analysis can identify if a project should be identified as actionable in the imminent ISP rather than in a future ISP. When a transmission project is declared as an actionable ISP project in an ISP, the project proponent is required to apply the regulatory investment tst for transmission (RIT-T) to that project[14]. For actionable ISP projects[15], a Project Assessment Draft Report (PADR) must be published by the date specified in the ISP, which must be at least six months after, and within 24 months of, the publication of the ISP[16]. For projects progressing under a jurisdictional framework rather than the ISP framework, proponents need to progress them through the relevant regulatory and approvals processes.

Because regulatory approval for large transmission projects can take several years, the actionable window is used to assess whether a project that was previously declared actionable should retain its actionable status from one ISP to the next. Figure 5 shows how the current *ISP Methodology* applies an increasing actionable window for every ISP in which a project maintains its actionable status.

Figure 5 Existing actionable window method



[14] NER 5.16A

[15] As detailed in the NER 5.22, an actionable ISP project relates to a transmission asset or non-network option the purpose of which is to address an identified need specified in an ISP and which forms part of the ODP.

[16] NER 5.22.6(a)(6)(i)(A)

In previous ISPs, the timing of each project was optimised in the capacity outlook models based on when it can provide the most value for customers, from its earliest in-service date (EISD) through the actionable window and onwards. This has meant testing the costs and benefits for multiple years within the actionable window.

Under this existing approach, AEMO has found that significant time and modelling effort is spent on optimising project timing within the actionable window for projects which have previously been identified as actionable. When a project is identified as actionable, it is identified as needing to to be progressed before the next ISP, including through commencing a RIT-T if it is an actionable ISP project. Projects previously identified as actionable have ordinarily already begun regulatory approvals, stakeholder engagement processes and other project development activities – in some cases this includes meaningful engagement programs with Traditional Owners and land councils, landholders, local communities, and environmental groups, as well as exploration of procurement activities, land use planning approvals and regulatory assessment studies. The relevant project proponent will have identified a proposed project delivery date which is informed by the outcomes of these activities.

AEMO considers that applying the project delivery date nominated by a project proponent and informed by regulatory and engagement activities already underway is likely to be a more efficient and appropriate way to test whether a project should be actionable in an imminient ISP, rather than undertaking optimisation studies for multiple years throughout the full actionable window. This would also strengthen alignment between the ISP and the ISP Feedback Loop for the project, where the proponent will seek AEMO's advice on whether the project remains aligned with the latest ISP prior to submitting a revenue application to the AER.

Proposed approach

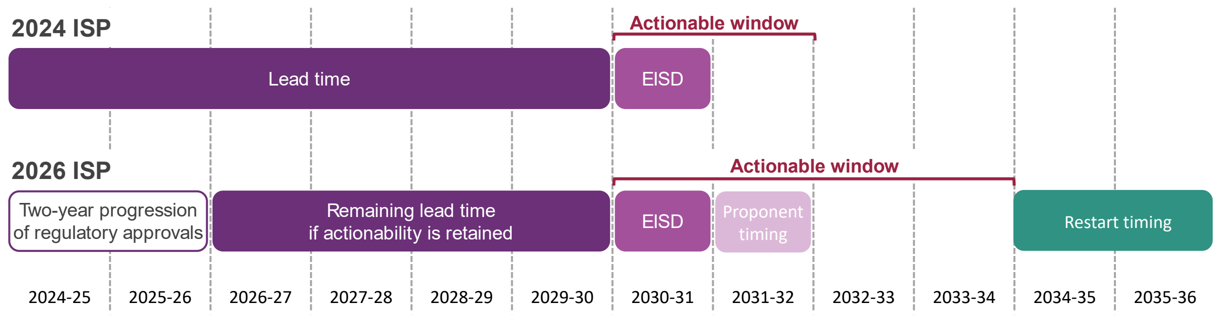
Testing at project proponent's timing

Rather than optimising project timing throughout the actionable window, for projects that have previously been identified as actionable, AEMO proposes to test for actionability at:

- **The proponent's timing** – the delivery date as advised by transmission project proponents, where that timing falls within the project's actionable window. This timing is informed by the outcome of regulatory investigations, engagement activities and other project development activities undertaken to progress a project after it has been previously identified as actionable.
- **The 'restart timing'** – after the end of the actionable window (as calculated by the length of time a project has held actionable status) plus a period that represents the additional time that would need to be added to the project's lead time if it were to be paused and then re-started later outside of the actionable window (see Figure 6 and text below).

AEMO considers that projects which have previously been identified as actionable (either actionable ISP projects or actionable projects progressing under a jurisdictional framework) should receive this treatment, as their project proponent's nominated delivery date will have been informed by regulatory and engagement activities already underway.

Figure 6 Possible impact of testing for actionability at project proponent timing and a 'restart' timing



Note: EISD is the 'earliest in-service date' nominated by the project proponent.

Determining restart timing

If AEMO tests a project's actionability by removing it from the ODP, this would be expected to delay the project to a period no earlier than its 'restart timing' after its actionable window. The restart timing would represent the additional time required to re-start a project after it has already been started, and then paused. This could include time to revisit feasibility studies, renew regulatory approvals, or initiate equipment procurement discussions with potentially longer delivery lead times.

AEMO would prepare the re-start timing as a parameter consulted on through the development of the *Network Expansion Options Report*, alongside other inputs and assumptions relating to transmission augmentation options. The *Network Expansion Options Report* is prepared through extensive collaboration and joint planning with transmission project proponents, including transmission network service providers and jurisdictional bodies.

Consultation questions

8. What are your views on AEMO's proposal to test previously-actionable projects for actionability at the project proponent's timing within the actionable window, and at a later re-start timing?

6.2. Allowing a broader assessment of benefits in take-one-out-at-a-time analysis

Existing approach

AEMO performs TOOT analysis on each actionable ISP project in the ODP under the most likely scenario. This involves removing the actionable ISP project from the ODP to form the TOOT 'base case', which is then optimised. The aim of this analysis is to provide an indication of the economic benefits the project can provide in that scenario.

For some actionable ISP projects which relate to flow paths in the NEM (either inter-connectors between regions, or intra-connectors within regions), there are REZ network augmentations situated along the route of that flow path. In those cases, the case for the development of the REZ network augmentation may depend on the flow path project. When undertaking TOOT analysis, it is assumed that developing the flow path would also allow the REZ network augmentation to occur without an associated cost. For this reason, the flow path and any dependent REZ networks augmentations are all removed when an actionable flow path project is taken out of the ODP.

AEMO considers that the current approach may be overlooking potentially actionable REZ augmentations in some cases by not evaluating their full benefits separately from the associated flow paths.

Proposed approach

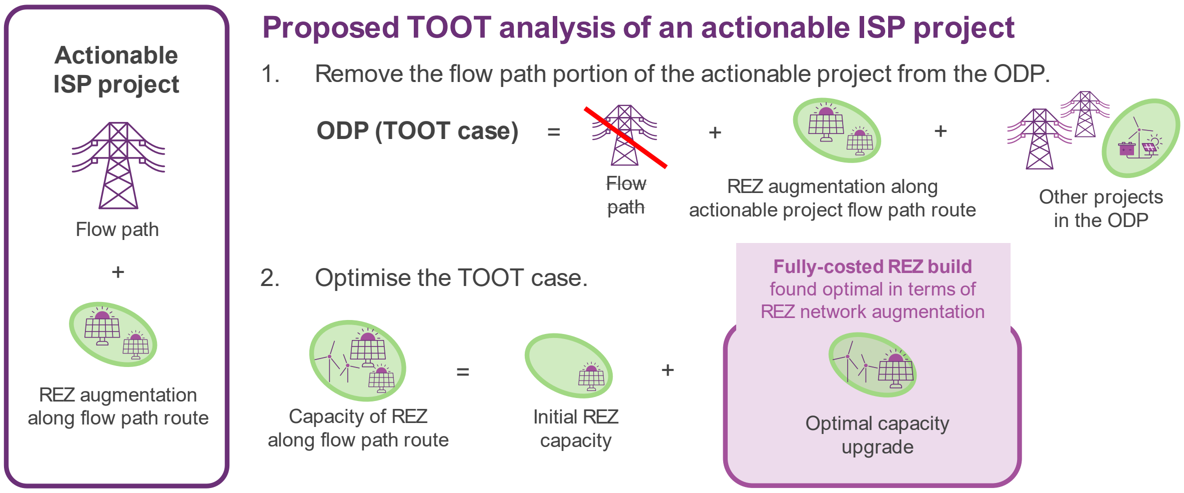
For select REZ augmentation options, AEMO proposes to remove the assumed dependency between flow paths and the REZ network augmentations along their route in the TOOT. Instead, TOOT analysis would:

- remove the flow path of interest and dependent REZ network augmentations from the ODP, and
- allow the model to optimise the capacity build and timing of any REZ network augmentations even if the flow path itself is not built, and include the full cost of the REZ network augmentations in the cost-benefit analysis.

AEMO considers that the select REZ augmentation options that should receive this treatment are those for which their costs and benefits might be strongly influenced by a proposed flow path augmentation, or the REZ augmentation in question is understood to be potentially moving in to an actionable timeframe.

The revised TOOT analysis method is shown in Figure 7.

Figure 7 Proposed process for take-one-out-at-a-time (TOOT) analysis



Under the existing approach, additional REZ limits and expansion costs are not assigned when the REZ network limits are set by the same network elements as the flow path. In these cases, the model relies on the flow path limits, upgrade costs and associated REZ increase amounts to avoid doubling up of costs for upgrading the same network elements.

AEMO proposes to develop separate REZ expansion costs that rely on some but not all of the flow path network element costs, and consult on them as part of the REZ expansion options detailed in the *Network Expansion Options Report*.

7. Enhancing selected ISP modelling approaches

AEMO has identified a number of potential enhancements across a range of selected existing ISP modelling approaches.

In this section:

- Section 7.1 proposes a measure to explore the issue of 'perfect foresight' for storage devices in the time-sequential model.
- Section 7.2 proposes an approach to enhance the ISP analysis of power system security.
- Section 7.3 adds the flexibility to model candidate REZs with large dispatchable loads.
- Section 7.4 adds the flexibility to better represent multiple wind resource types within a candidate REZ.

7.1. Addressing perfect foresight for storage devices in the time-sequential model

Existing approach

The capacity outlook and time-sequential models applied by AEMO to produce the ISP include inherent 'perfect foresight' in dispatch and capacity optimisation. This is a known challenge associated with this form of market modelling, whereby project proponents' decisions are optimised with perfect foresight of supply and demand conditions on each simulated day plus a look-ahead period. As a result, the model anticipates perfect energy management and the ideal dispatch of storage technologies from market participants across the modelling horizon. In reality, battery operators make dispatch decisions with uncertainty about market conditions in future periods. The risk management involved in deciding to dispatch energy now versus missing out on a higher-price interval later leads batteries (and other short-duration storage devices) to be dispatched in reality at lower capacity rates than perfect foresight modelling suggests – or potentially not at all, even when this dispatch may be required by the power system.

The 2023 *ISP Methodology* allowed for the option to apply limits to the storage duration (megawatt hours (MWh)) of storage devices in the time-sequential model to explore the implications of this 'perfect foresight' issue. This option allowed for exploration of these devices not being operated to exclusively meet immediate power system needs, and to validate the operability of CDPs. This was intended to reflect the notion that some energy would be used before the time of optimal need, or else reserved for use in future periods, such that storage devices could not discharge thier full energy capacity. Results from the 2024 ISP modelling suggested this approach of derating stored energy is most impactful during long winter periods of high residual demand when the total energy at the system level depletes. During other short and sporadic periods of low reserve conditions, batteries in the model were still dispatched to a 'perfect' schedule.

Proposed approach

To better represent the potential for suboptimal dispatch outcomes that may eventuate due to energy storage operational plans and risk mitigation strategies that utilise uncertain forecast information, AEMO proposes to incorporate the following two approaches in the ISP. These approaches will be implemented in time-sequential modelling to provide insight into the impact of imperfect foresight, particularly ahead of long winter periods of high residual demand.

(a) **Headroom and footroom reservation** – introduce headroom and footroom energy reserves to storage devices, wherein a small margin of energy at the upper and lower states of charge remains accessible only if required during conditions that would otherwise result in unserved energy. This would provide increased flexibility to storage devices to respond (either charging or discharging) to a future unforeseen network event should it arise, and would restrict storage devices from optimally using their full energy capacity. This would be the default application of imperfect foresight modelling.

(b) **Energy planning with error** – apply imperfect assumptions of generator outages, renewable energy availability and demand conditions to the short-term energy plan that influences storage operation. In this approach, storage devices would plan their states of charge according to an inaccurate – or imperfect – dispatch schedule. When an unexpected period of energy scarcity occurs due to weather forecast uncertainty or an unplanned outage, the energy levels of storage devices may not be sufficiently high enough for the storage devices to contribute maximally into that period. The same 'imperfect' energy plan would be applied to different weather reference years to validate the capability of the generation, storage and transmission investments using the time-sequential model.

AEMO proposes that the same method would be applied for distributed storages (virtual power plants (VPPs) and vehicle-to-grid EVs) as well as utility-scale battery energy storage systems, as aggregated energy storages are modelled consistently with large-scale energy storage devices in the ISP.

Consultation questions

9. Do you agree with AEMO's proposed approach to model storage devices with headroom and footroom energy reserves and imperfect energy targets in the time-sequential modelling component? What improvements should be made to model energy storage limits to better reflect actual behaviour and address issues of 'perfect foresight'? Please provide any supporting evidence.

7.2. Enhancing analysis of system security

Existing approach

System strength

The system strength[17] standard specification comprises both a minimum three phase fault level for power system security, and an efficient level of system strength which is the requirement for stable voltage waveforms at connection points[18].

AEMO publishes power system constraints reflecting the minimum level of system strength requirement that sets a minimum number of synchronous generating units that must be observed. This constraint is taken into consideration by manually checking the results as part of the SSLT to DLT process, in which coal retirements are determined.

Under the existing approach, AEMO does includes system strength costs in the ISP to meet the efficient level of system strength (but not the minimum three phase fault level requirement, which is assumed to be met

[17] Definitions of power system requirements such as system strength can be found in AEMO's *Power System Requirements* report, July 2020, at https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Power-system-requirements.pdf.

[18] AEMO, System Strength Requirements Methodology. December 2022, at https://aemo.com.au/-/media/files/electricity/nem/security_and_reliability/system-strength-requirements/system-strength-requirements-methodology.pdf.

separately through the system strength requirements framework). The efficient level of system strength is incorporated as either additional build cost on new entrant VRE or on REZ network augmentation in the capacity outlook modelling. These costs are based on synchronous condenser technology as an existing, commercialy viable technology demonstrated at scale.

Inertia

Inertia[19] in the ISP is currently assessed using time-sequential analysis to project the expected inertia online and compared with the relevant inertia requirements for each region to estimate any inertia shortfalls.

Network augmentation

AEMO verifies that all network augmentations are designed to ensure system security and reliability. This analysis is performed by taking the capacity outlook and time-sequential outcomes and investigating the performance of the network, to identify whether:

- Network equipment remains within thermal ratings. Transmission network service providers (TNSPs) provide transmission line and transformer ratings for different ambient temperatures, seasons, months, and times of day, which are considered by AEMO when performing network capability assessments. AEMO determines secure operating limits by applying continuous normal ratings, contingency ratings, and short-term ratings for post-contingency conditions.
- When required, measures such as static or dynamic reactive compensation are also designed and costed as part of network augmentations to meet voltage requirements and improve stability limits.

Proposed approach

In their response to the Review of the ISP, Energy Ministers called for "*greater consideration of system security in assessing the optimal mix of generation, storage, transmission and other infrastructure*".

Currently, the model does not calculate the cost of meeting the minimum fault level – it only considers the cost of meeting the efficient level of system strength, by assuming that synchronous condensers will be delivered to meet the efficient level. AEMO proposes to reformulate the current system security constraint to allow synchronous condensers to replace retiring synchronous machines to meet the minimum unit requirement as well, rather than the current approach which assumes that as synchronous machines retire synchronous condensers (or their equivalent) will be delivered through the separate system strength framework to meet the minimum fault level requirements. For example, as coal retires and if the constraint were to bind, it would require new synchronous condensers to be built in the ISP model to meet the requirements at the system strength nodes.

AEMO expects that the cost of meeting both the minimum and efficient levels of system strength levels will decline over time to reflect improvements in technology and fewer supply chain restrictions out to 2050. This cost reduction over time would reflect the increasing availability and capacity of inverter-based resource (IBR) generation capable of providing system strength and their potential to provide 'protection quality' fault current.

AEMO considers that the reformulated constraint will sufficiently meet inertia requirements as well as system strength, as the cost of enabling synchronous condensers or grid-forming inverters to provide inertia is a small incremental cost.

[19] Definitions of power system security requirements such as inertia can be found in AEMO's *Power System Requirements* report, July 2020, accessible via https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Power-system-requirements.pdf.

AEMO could then provide further detail and unbundle the costs for meeting the different system strength requirements over the modelling horizon to the 2050s.

AEMO also intends to assess inertia against both the islanded sub-network requirements, and the system-wide inertia requirements in line with the Improved Security Framework rule change[20].

Consultation questions

10. What risks should AEMO consider when assessing how IBR can complement synchronous machines in providing system strength and inertia?

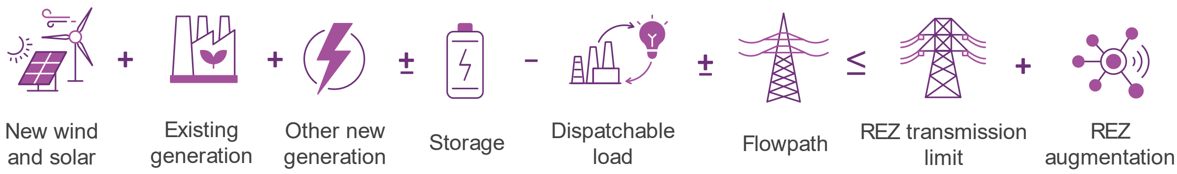
11. Do you agree with AEMO's proposed approach for uplifting cost and modelling representation for system security services in the ISP? If not, what alternative methods would you recommend? Please provide any supporting evidence.

7.3. Modelling directional renewable energy zone transmission constraints

Existing approach

AEMO applies several REZ transmission limit constraints (as well as group constraints[21]) in the ISP to model the export capacity of the transmission for each REZ. These REZ constraints effectively limit generation dispatch up to the REZ transmission limit, which can be increased if found economically optimal. These constraints take the following form:

Figure 8 Representation of a REZ transmission constraint



$$Gen_{New,Solar} + Gen_{New,Wind} + Gen_{Existing} + Gen_{New,other} + Discharge_{Storage} - Charge_{Storage} - Load_{Dispatchable} + Flow_{Flowpath} \leq REZ\ Transmission\ limit + REZ\ augmentation$$

Where:

- $Gen_{New,Solar}$ is the generation from new entrant solar capacity.
- $Gen_{New,wind}$ is the generation from new entrant wind capacity.
- $Gen_{Existing}$ is the generation from relevant existing VRE and fossil-fuelled generation and may be included if this generation would materially affect the use of the REZ transmission network and the need for augmentation.

[20] See https://www.aemc.gov.au/rule-changes/improving-security-frameworks-energy-transition.

[21] Group constraints combine the generation output and transmission limits from more than one REZ to reflect transmission limits that apply to wide areas of the power system. They are developed by considering the limits observed from power system analysis, and in consultation with TNSPs.

- $Gen_{New,other}$ is the generation from relevant new entrant generation that are not solar or wind technologies and may be included if this generation would materially affect the use of REZ transmission network and the need for augmentation.
- $Discharge_{Storage}$ and $Charge_{Storage}$ are the discharge/generation and charge/pumping of any large-scale energy storage or pumped hydro energy storage (PHES) that is located within the REZ respectively.
- $Load_{Dispatchable}$ represents dispatchable loads (other than storage), for example potentially hydrogen electrolysers that are explicitly modelled, and located within the REZ. This term will be applied only if it will significantly improve the modelling of the REZ transmission limit.
- $Flow_{Flowpath}$ captures the impact of the instantaneous flow across any any relevant major transmission flow path on the use of the REZ transmission network and the need for augmentation.
- $REZ\ Transmission\ limit$ reflects the maximum export limit of the existing network at the point(s) where the REZ output may be constrained. This value changes in cases where transmission developments improve access to the REZ.
- $REZ\ augmentation$ reflects the additional network capacity available as a result of transmission developments between the NEM transmission network and the REZ.

These constraints limit flows out (export) of a given REZ, and allow for large dispatchable loads to be included within the REZ to be supplied from generation and storage within the REZ. However, these constraints do not currently represent limitations on flow in to a REZ (import).

Proposed approach

AEMO proposes to introduce a separate REZ transmission constraint to accommodate appropriate treatment of import limitations (the reverse direction, see equation below) into the REZ and corresponding augmentation options. This is expected to be applicable only for REZs with large dispatchable loads.

$$Load_{Dispatchable} - Gen_{New,Solar} - Gen_{New,Wind} - Gen_{Existing} - Gen_{New,other} - Discharge_{Storage} + Charge_{Storage} \leq REZ\ Transmission\ limit + REZ\ augmentation$$

Similar to the REZ export constraint, the above constraint effectively links the degree of imports with the potential need to augment a REZ. Note that depending on network topology, some REZ network augmentation options may improve the REZ transmission capacity in both directions (into the REZ and out of the REZ).

Together, both REZ transmission constraints would provide bi-directional limits for the ISP model to optimise REZ expansion.

7.4. Improving representation of wind resource diversity in large renewable energy zones

Existing approach

AEMO represents the wind resource available in each candidate REZ in two tranches, to represent the resource quality differences that are observed in the mesoscale data. Under the current approach, the first tranche represents the highest quality wind resource, and the second tranche represents the remaining good quality resource. This enables some consideration of the variance that can exist in wind resources across REZs' geographical areas.

However, some existing REZs considered in previous ISPs cover very large geographical areas such that using only two tranches of wind resources may not sufficiently represent the variety of resources across those REZs.

Proposed approach

AEMO proposes to, when appropriate and depending on the REZ, allow for inclusion of more than two wind resource tranches in some REZs. This would recognise the fact that two resource tranches may not provide enough representation of resource diversity across a large geographical area.

Consultation questions

12. Do you agree with AEMO's proposal to model more than two wind resource quality tranches for geographically large REZs? If not, what alternatives should AEMO consider?

Glossary

This glossary has been prepared as a quick guide to help readers understand some of the terms used in the ISP. Words and phrases defined in the National Electricity Rules (NER) have the meaning given to them in the NER. This glossary is not a substitute for consulting the NER, the AER's Cost Benefit Analysis Guidelines, or AEMO's *ISP Methodology*.

Term	Acronym	Explanation
Actionable ISP project	-	Actionable ISP projects optimise benefits for consumers if progressed before the next ISP. A transmission project (or non-network option) identified as part of the optimal development path (ODP) and having a delivery date within an actionable window. For newly actionable ISP projects, the actionable window is two years, meaning it is within the window if the project is needed within two years of its earliest in-service date (EISD). The window is longer for projects that have previously been actionable. Project proponents are required to begin newly actionable ISP projects with the release of a final ISP, including commencing a RIT-T.
Actionable project progressing under a jurisdictional framework	-	A transmission project (or non-network option) that optimises benefits for consumers if progressed before the next ISP, is identified as part of the optimal development path (ODP), and is supported by or committed to in policy and/or prospective or current legislation under a jurisdictional framework.
Anticipated project	-	A generation, storage or transmission project that is in the process of meeting at least three of the five commitment criteria (planning, construction, land, contracts, finance), in accordance with the AER's Cost Benefit Analysis Guidelines. Anticipated projects are included in all ISP scenarios.
Candidate development path	CDP	A collection of development paths which share a set of potential actionable projects. Within the collection, potential future ISP projects are allowed to vary across scenarios between the development paths. Candidate development paths have been shortlisted for selection as the optimal development path (ODP) and are evaluated in detail to determine the ODP, in accordance with the *ISP Methodology*.
Capacity	-	The maximum rating of a generating or storage unit (or set of generating units), or transmission line, typically expressed in megawatts (MW). For example, a solar farm may have a nominal capacity of 400 MW.
Committed project	-	A generation, storage or transmission project that has fully met all five commitment criteria (planning, construction, land, contracts, finance), in accordance with the AER's Cost Benefit Analysis Guidelines. Committed projects are included in all ISP scenarios.
Consumer energy resources	CER	Generation or storage assets owned by consumers and installed behind-the-meter. These can include rooftop solar, batteries and electric vehicles (EVs).
Consumption	-	The electrical energy used over a period of time (for example a day or year). This quantity is typically expressed in megawatt hours (MWh) or its multiples. Various definitions for consumption apply, depending on where it is measured. For example, underlying consumption means consumption being supplied by both consumer energy resources (CER) and the electricity grid.
Cost-benefit analysis	CBA	A comparison of the quantified costs and benefits of a particular project (or suite of projects) in monetary terms. For the ISP, a cost-benefit analysis is conducted in accordance with the AER's Cost Benefit Analysis Guidelines.
Counterfactual development path	-	The counterfactual development path represents a future without major transmission augmentation. AEMO compares candidate development paths (CDPs) against the counterfactual to calculate the economic benefits of transmission.

Term	Acronym	Explanation
Demand	-	The amount of electrical power consumed at a point in time. This quantity is typically expressed in megawatts (MW) or its multiples. Various definitions for demand, depending on where it is measured. For example, underlying demand means demand supplied by both consumer energy resources (CER) and the electricity grid.
Development path	DP	A set of projects (actionable projects, future projects and ISP development opportunities) in an ISP that together address power system needs.
Dispatchable load	-	The total amount of load that can be turned on or off, without being dependent on the weather. Dispatchable load can help to ensure system security during periods of low variable renewable energy output in the NEM.
Distributed solar/ distributed PV	-	Solar photovoltaic (PV) generation assets that are not centrally controlled by AEMO dispatch. Examples include residential and business rooftop PV as well as larger commercial or industrial "non-scheduled" PV systems.
Firming	-	Grid-connected assets that can provide dispatchable capacity when variable renewable energy generation is limited by weather, for example storage (pumped-hydro and batteries) and gas-powered generation.
Future ISP project	-	A transmission project (or non-network option) that addresses an identified need in the ISP, that is part of the optimal development path (ODP), and is forecast to be actionable in the future.
Identified need	-	The objective a transmission network service provider (TNSP) seeks to achieve by investing in the network in accordance with the NER or an ISP. In the context of the ISP, the identified need is the reason an investment in the network is required, and may be met by either a network or a non-network option.
ISP development opportunity	-	A development identified in the ISP that does not relate to a transmission project (or non-network option) and may include generation, storage, demand-side participation, or other developments such as distribution network projects.
Net market benefits	-	The present value of total market benefits associated with a project (or a group of projects), less its total cost, calculated in accordance with the AER's Cost Benefit Analysis Guidelines.
Non-network option	-	A means by which an identified need can be fully or partly addressed, that is not a network option. A network option means a solution such as transmission lines or substations which are undertaken by a network service provider using regulated expenditure.
Optimal development path	ODP	The development path identified in the ISP as optimal and robust to future states of the world. The ODP contains actionable projects, future ISP projects and ISP development opportunities, and optimises costs and benefits of various options across a range of future ISP scenarios.
Regulatory Investment Test for Transmission	RIT-T	The RIT-T is a cost benefit analysis test that transmission network service providers (TNSPs) must apply to prescribed regulated investments in their network. The purpose of the RIT-T is to identify the credible network or non-network options to address the identified network need that maximise net market benefits to the NEM. RIT-Ts are required for some but not all transmission investments.
Reliable (power system)	-	The ability of the power system to supply adequate power to satisfy consumer demand, allowing for credible generation and transmission network contingencies.
Renewable energy	-	For the purposes of the ISP, the following technologies are referred to under the grouping of renewable energy: "solar, wind, biomass, hydro, and hydrogen turbines". Variable renewable energy (VRE) is a subset of this group, explained below.
Renewable energy zone	REZ	An area identified in the ISP as high-quality resource areas where clusters of large-scale renewable energy projects can be developed using economies of scale.

Term	Acronym	Explanation
Scenario	-	A possible future of how the NEM may develop to meet a set of conditions that influence consumer demand, economic activity, decarbonisation, and other parameters. For the 2024 ISP, AEMO considered three scenarios: *Progressive Change*, *Step Change* and *Green Energy Exports*.
Secure (power system)	-	The system is secure if it is operating within defined technical limits and is able to be returned to within those limits after a major power system element is disconnected (such as a generator or a major transmission network element).
Sensitivity analysis	-	Analysis undertaken to determine how modelling outcomes change if an input assumption (or a collection of related input assumptions) is changed.
Transmission network service provider	TNSP	A business responsible for owning, controlling or operating a transmission network.
Utility-scale or utility		For the purposes of the ISP, 'utility-scale' and 'utility' refers to technologies connected to the high-voltage power system rather than behind the meter at a business or residence.
Value of greenhouse gas emissions reduction	VER	The VER estimates the value (dollar per tonne) of avoided greenhouse gas emissions. The VER is calculated consistent with the method agreed to by Australia's Energy Ministers in February 2024.
Virtual power plant	VPP	An aggregation of resources coordinated to deliver services for power system operations and electricity markets. For the ISP, VPPs enable coordinated control of consumer energy resources (CER), including batteries and electric vehicles (EVs).
Variable renewable energy	VRE	Renewable resources whose generation output can vary greatly in short time periods due to changing weather conditions, such as solar and wind.