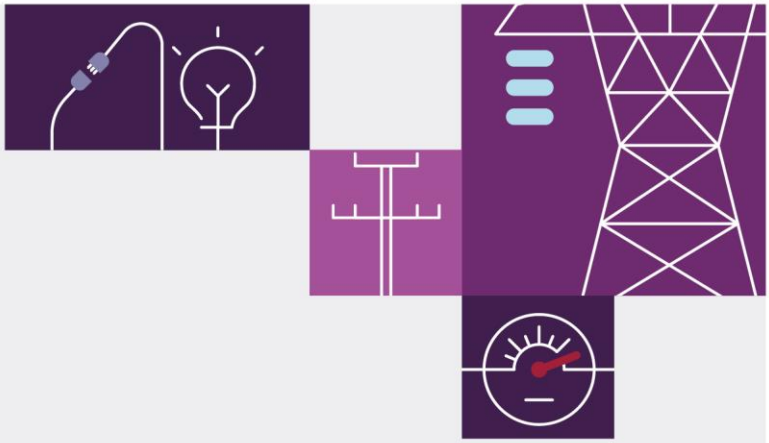
AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

2023 IASR Consultation Summary Report

28 July 2023

For the National Electricity Market



Important notice

Purpose

AEMO publishes this 2023 IASR Consultation Summary Report pursuant to National Electricity Rules (NER) 5.22.8 and the Australian Energy Regulator's Forecasting Best Practice Guidelines. This report summarises the material issues raised by stakeholders during consultation on the 2023 *Inputs, Assumptions and Scenarios Repor*t and provides AEMO's response to each issue. This report should be read together with the 2023 *Inputs, Assumptions and Scenarios Report*.

Disclaimer

AEMO has made reasonable efforts to ensure the quality of information in this report, but cannot guarantee that information, forecasts and assumptions are accurate, complete or appropriate for your circumstances. This document does not constitute legal or business advice, and should not be relied on as a substitute for obtaining detailed advice about the National Electricity Law, the National Electricity Rules, or any other applicable laws, procedures or policies.

Anyone proposing to use the information in this publication (which includes information and forecasts from third parties) should independently verify its accuracy, completeness and suitability for purpose, and obtain independent and specific advice from appropriate experts.

Accordingly, to the maximum extent permitted by law, AEMO and its officers, employees and consultants involved in the preparation of this document:

- make no representation or warranty, express or implied, as to the currency, accuracy, reliability or completeness of the information in this document; and
- are not liable (whether by reason of negligence or otherwise) for any statements or representations in this document, or any omissions from it, or for any use or reliance on the information in it.

Acknowledgment

AEMO acknowledges the support, co-operation and contribution of numerous participants in providing valuable suggestions and feedback to the scenarios and their inputs and assumptions contained within the Draft 2023 IASR consultation.

Copyright

AEMO acknowledges the Traditional Owners of country throughout Australia and recognises their continuing connection to land, waters and culture. We pay respect to Elders past and present.

Contents

Tables

Figures

1 Introduction

AEMO delivers a range of forecasting and planning publications for the National Electricity Market (NEM), including the NEM *Electricity Statement of Opportunities* (ESOO), *Gas Statement of Opportunities* (GSOO), and *Integrated System Plan* (ISP). AEMO uses a common set of inputs, assumptions and scenarios in developing these publications.

Every year, AEMO works with stakeholders to update the inputs and assumptions that will be used in AEMO's development of a number of major planning and forecasting publications for the year ahead. The 2023 *Inputs, Assumptions and Scenarios Report* (2023 IASR), which this document accompanies, outlines the scenarios, modelling inputs and assumptions that AEMO will use in its forecasting and planning activities over the coming year, including the development of the 2024 ISP.

AEMO consulted on the Draft 2023 IASR in accordance with the National Electricity Rules (NER) and the Australian Energy Regulator's (AER's) Forecasting Best Practice Guidelines[1].

This document summarises the material issues raised by stakeholders, AEMO's response to stakeholder feedback, and the changes taken into account in the 2023 IASR.

The document is divided into the following sections to group key areas of stakeholder feedback and summarise AEMO's response and decisions to that feedback:

- Section 2 – feedback on scenarios and sensitivities, and AEMO's updated scenario collection.
- Section 3 – summary feedback on key inputs and assumptions.

There is a glossary of terms and abbreviations in Appendix A.

1.1 Stakeholder feedback was key to drafting and finalising the 2023 IASR

Recognising the pace of change and stakeholders' appetite to inform the ISP, AEMO hosted several engagement opportunities following the publication of the 2022 ISP in July 2022. These activities focused on informing refinements to the scenarios that should be adopted in the 2024 ISP.

In developing the scenarios and their inputs prior to publication of the Draft 2023 IASR in December 2022, AEMO frequently engaged with the Forecasting Reference Group (FRG) to receive early feedback on preliminary forecast components, such as the economic outlook, decarbonisation insights through multi-sector modelling, and consumer energy resources.

AEMO received formal submissions to the Draft 2023 IASR consultation from over 60 organisations and individuals, and thanks stakeholders for their feedback on this critical planning publication. AEMO also engaged with the following organisations to assist in evolving the Draft IASR's scenario collection, potential sensitivities, and technical settings to be applied as inputs to each of the scenarios:

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

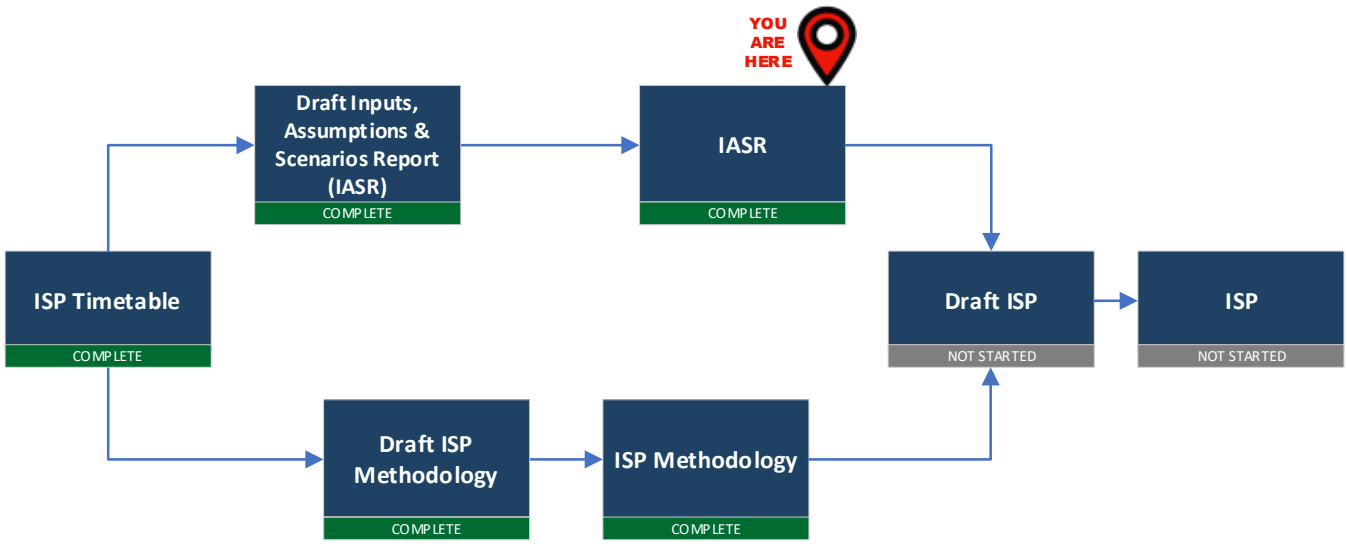
- The ISP Consumer Panel and AEMO's newly formed Advisory Council on Social Licence.
- Transmission network service providers (TNSPs) who provide key technical input and opinion under AEMO's joint planning functions.
- Distribution network service providers (DNSPs) through the DNSP-ISP working group.
- Various organisations that have supported the development of the scenarios and their assumptions, and engaged directly with AEMO to expand on their submission topics and/or provide unique expertise that AEMO has considered in refining the IASR.

1.1.1 2024 ISP development process

Figure 1 below shows the status of two consultations that are relevant to this IASR, in so far as they support the 2024 ISP. Before developing and consulting on the Draft 2022 ISP, AEMO led activities to:

- **Consult on the 2023 inputs, assumptions and scenarios** – AEMO received 64 stakeholder submissions on the Draft 2023 IASR. This Consultation Summary Report provides context for AEMO's consideration of these submissions. AEMO also received 5 confidential submissions. As a subset of the IASR, AEMO also consulted on the 2023 *Transmission Expansions Options Report*, receiving 20 written submissions, two confidential submissions, and a submission provided verbally by consumer advocates[2].
- **Consult on the 2024 ISP Methodology updates** – AEMO received 25 stakeholder submissions on the Draft ISP Methodology that was published in March 2023. AEMO released the final ISP Methodology on 30 June 2023[3].

Figure 1 Parallel ISP consultations



[2] Consultation materials for the 2023 *Transmission Expansion Options Report* are available at https://aemo.com.au/consultations/current-and-closed-consultations/2023-transmission-expansion-options-report-consultation.

[3] Consultation materials for the 2023 ISP Methodology are available at https://aemo.com.au/consultations/current-and-closed-consultations/consultation-on-updates-to-the-isp-methodology.

In addition to these three AEMO-led consultations, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) led the development of the ***GenCost 2022-23 Final report***[4], which has also been finalised and published alongside this IASR. CSIRO received five additional stakeholder submissions, in addition to relevant submissions provided to this IASR.

Key engagement milestones for the Draft 2023 IASR consultation are summarised in Table 1.

Table 1 Consultation process and timeline

Consultation steps	Dates
Engagement on key topics for the 2023 IASR at FRG meetings	23 Feb, 30 Mar 2022
Scenarios webinars	13 Jul, 31 Aug 2022
FRG meetings exploring specific inputs	31 Aug, 21 Sep, 28 Sep 2022
Draft 2023 IASR published	16 Dec 2022
What is the ISP and why does it matter to consumers webinar	24 Jan 2023
Pre submissions public webinar	2 Feb 2023
Consumer Advocate verbal consultation submission session	9 Feb 2023
Submissions closed on consultation paper	16 Feb 2023
Submissions reflection webinar	22 Mar 2023
FRG meetings exploring specific inputs	29 Mar, 28 Jun 2023
Transmission Expansion Options Report consultation	May - Jul 2023
Scenarios and sensitivities update webinar	15 June 2023
Final report published	28 Jul 2023

While the IASR is used broadly when assessing Australia's highly complex and rapid energy transition, it is a critical input to the 2024 ISP. Figure 2 shows the ISP process, and current progress on all elements for the 2024 ISP[5].

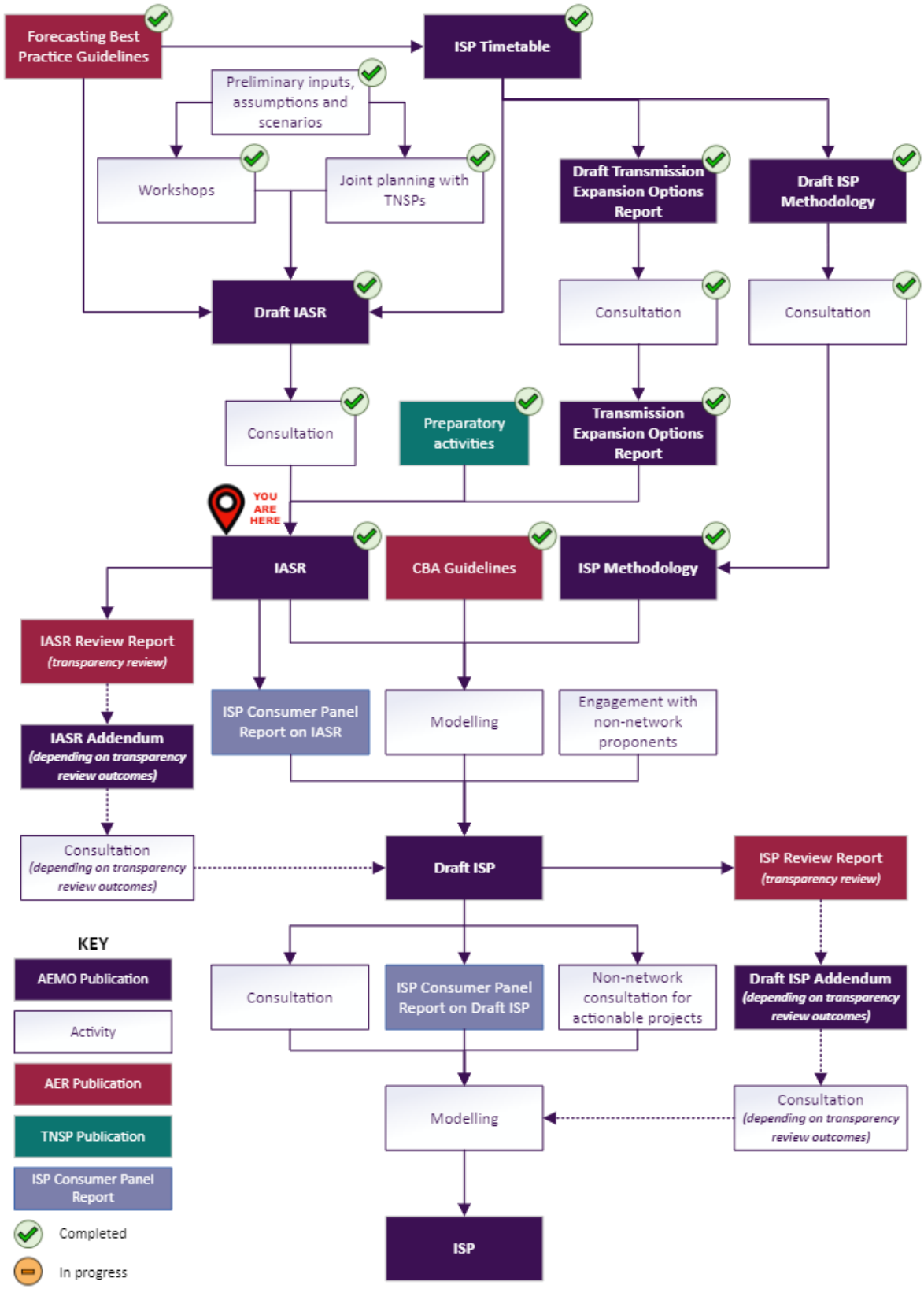
AEMO's 2023 IASR consultation webpage[6] contains all published papers and reports, written submissions, webinar recordings, and other consultation documents and reference material (other than material identified as confidential).

[4] At https://doi.org/10.25919/zmvj-tj87.

[5] The 2024 ISP Timetable provides more information on the key milestones of the 2024 ISP development process, at https://aemo.com.au/-/media/files/major-publications/isp/2022/2024-isp-timetable.pdf?la=en

[6] At https://aemo.com.au/consultations/current-and-closed-consultations/2023-inputs-assumptions-and-scenarios-consultation. The most recent published IASR is on AEMO's web page for current inputs, assumptions and scenarios, at https://aemo.com.au/energy-systems/major-publications/integrated-system-plan-isp/2022-integrated-system-plan-isp/current-inputs-assumptions-and-scenarios.

Figure 2 Navigating the ISP process



Note: The diagram above has been amended from the version published in the 2024 ISP timetable by adding a box containing "Draft Transmission Expansion Options Report" and "Transmission Expansion Options Report" with an additional "Consultation" box. The IASR will consider transmission development options and non-network alternatives.

1.2 Summary of stakeholder feedback

1.2.1 AEMO received over 60 submissions to the formal consultation opportunity

In response to the Draft 2023 IASR consultation, AEMO received 64 published submissions, and five confidential submissions. Stakeholders who provided non-confidential submissions are listed in Table 2.

Table 2 Stakeholders who provided submissions to the Draft 2023 IASR

APA	ElectraNet	Moyne Shire Council
Australian Pipelines and Gas Association (APGA)	Electric Vehicle Council (EVC)	Origin Energy
Ausgrid	Energy Networks Australia (ENA)	Public Interest Advocacy Centre (PIAC)
AusNet Services	Energetic Communities	Powerlink
Australian Conservation Foundation (ACF)	EnergyAustralia	Queensland Energy Users Network (QEUN)
Australian Resources Development (ARDL)	Energy Consumers Australia (ECA)	Queensland Conservation Council (QCC)
Australian Solar Thermal Research Institute, Fichtner Engineering & ITP Thermal (ASTRI, Fichtner and ITP)	Energy Efficiency Council (EEC)	RE-Alliance
Barrie Hill	Energy Grid Alliance (EGA)	Rheem & Combined Energy Technologies
Beyond Zero Emissions (BZE)	Etrog Consulting	Save Our Surroundings (SOS)
Bob King	Fortescue Future Industries (FFI)	Shell Energy
Brotherhood of St Laurence (BSL)	Friends of the Earth	Simon Bartlett
CitiPower, Powercor & United Energy	Harry Audus	Smart Energy Council (SEC)
Clean Energy Council (CEC)	Hunter Jobs Alliance	SMR Nuclear Technology
Clean Energy Investor Group (CEIG)	Hydro Tasmania	Snowy Hydro
Climate Action Network Australia (CANA)	Iberdrola	Star of the South
Climate Council	ISP Consumer Panel	TasNetworks
ClimateWorks Centre (CWC)	John Diesendorf	Transgrid
Community Power Agency (CPA)	Joy Duncan	Victorian Bioenergy Network (VBN)
COTA Tasmania	Mackay Conservation Group	Victorian Farmers Federation (VFF)
Darach Energy Consulting Services	MarinusLink	Wanda Grabowski
Delta Electricity	Monash Digital Energy Futures	Windlab
		World Wide Fund for Nature (WWF)

AEMO considered these submissions and other relevant information in developing the 2023 IASR. Sections 2 and 3 of this document detail AEMO's responses and the changes from the Draft 2023 IASR based on stakeholder feedback.

AEMO thanks all stakeholders for their feedback throughout the development of the 2023 IASR.

1.2.2 Key themes submitted

Figure 3 and Table 3 below summarise the key topics on which stakeholders provided feedback.

Figure 3 Submissions received by topic

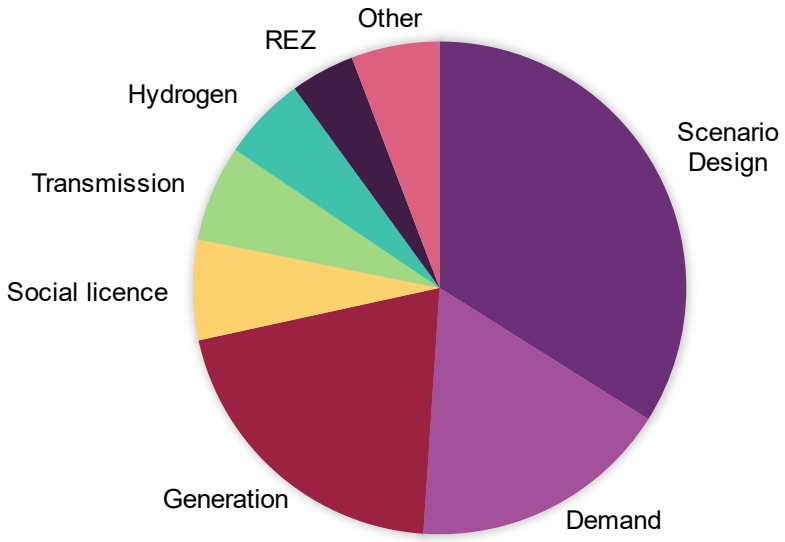


Table 3 Summary of feedback by topic

Theme	Description	Submitter(s)
Scenario design	• Support for exploration of electrification-focused scenarios and/or sensitivities, particularly those that achieve, or support, a 1.5°C outcome. • Concern that the *Green Energy Exports* assumption of up to 100% blending of hydrogen in the existing gas distribution network is unrealistic due to technical and financial reasons. • Concern that the *Progressive Change* scenario yielded insufficient carbon reduction and the resulting temperature increase was inconsistent with Australia's international commitments. • Support for sensitivity analysis to explore different levels of social licence. • Mixed views on the value of the *Progressive Change* scenario.	FFI, CEC, Energetic Communities, ACF, ISP Consumer Panel, BSL, Climate council, COTA Tasmania, Darach Energy Consulting Services, Etrog Consulting, QEUN, Origin Energy, Ausgrid, BZE, Friends of the Earth, Powerlink, RE-Alliance, CitiPower, Powercor, United Energy, CPA, Hydro Tasmania, John Diesendorf, PIAC, WWF, CEIG, CANA, CWC, Delta, Harry Adus, Iberdrola, MacKay Conservation Group, Monash Digital Energy Future, QCC, Shell, Simon Bartlett, SEC, Snowy, Transgrid, Wanda Grabowski, Joy Duncan, Rheem, Combined Energy, AusNet
Demand	• Stakeholders raised that further consideration was required for costing consumer investment decisions and consumer behaviours, especially the costs to convert appliances; technical barriers for load transformation such as space limitations; or process-heat requirements, individual investment decisions of firms; network augmentation costs; and costs of stranded gas assets. • Submissions highlighted interest in the detail, level and policy options for energy efficiency. • Responses included suggestions to include committed and prospective large industrial	FFI, ISP Consumer Panel, RE-Alliance, EVC, Shell, VBN, Energetic Communities, ACF, BSL, Climate council, COTA Tasmania, Darach Energy Consulting Services, Etrog Consulting, QEUN, CitiPower, Powercor, United Energy, APA, ElectraNet, Rheem, Combined Energy, CEC, Ausgrid, BZE, Powerlink, Hydro Tasmania, Simon Bartlett, SEC, Snowy, Transgrid, AGPA, ECA, EEC, ENA, EnergyAustralia, TasNetworks

Theme	Description	Submitter(s)
	loads to capture the high load growth expected in some regions. • Additionally, feedback identified the importance of using the most current possible economic and population drivers as drivers for load growth.	
Generation	• Suggestions for additional or alternative candidate technologies such as compressed air storages, small modular reactors. • Comments that wind farm capacity factors for South West New South Wales REZ are too low and Far North Queensland are too high. • Feedback on the assumptions for the duration of the current supply chain constraints when deriving build cost trajectories, as well as the derivation of locational cost factors and their treatment of land costs.	ISP Consumer Panel, FFI, CEC, VBN, Bob King, Simon Bartlett, Shell, Hydro Tasmania, Snowy, ASTRI, Fichtner and ITP, Marinus Link, RE-Alliance, ACF, BSL, Climate council, COTA Tasmania, Darach Energy Consulting Services, Etrog Consulting, QEUN, SEC, Transgrid, EnergyAustralia, Origin Energy, Iberdrola, Australian Resource Dev, Barrie Hill, Star of the South, Windlab, FFI, CEC, VBN, Snowy, BSL, Climate council, COTA Tasmania, Darach Energy Consulting Services, Etrog Consulting, QEUN, EnergyAustralia, Iberdrola, SOS
Social licence	• Many submitters welcomed the Draft 2023 IASR's consideration of social licence as an input to the ISP, and the establishment of the Advisory Council on Social Licence. AEMO's proposal on quantifying social licence into economic modelling (considering land use penalty factors, project lead time and transmission augmentation costs) was largely agreed with a few suggestions. Below are some themes and suggestions from submissions: – Social licence as a sensitivity: ▪ There was strong support for AEMO to apply a social licence sensitivity, where transmission costs and timelines are increased substantially due to difficulty approving projects. ▪ Some respondents suggested a sensitivity where 50% of developments are cancelled. This could be a "worst-case" scenario. – Project lead time: ▪ Stakeholders broadly supported applying a sensitivity to reflect longer lead times (project execution, commissioning delays, and more early community engagement). – Land use penalty factors: ▪ Many submitters disagreed with the use of land use-penalty factors and suggested AEMO apply strategic land use mapping analysis (by TNSPs or others) and a detailed multi-criteria analysis (MCA). ▪ Some stakeholders agreed with the proposed $0.27M/MW value, while some stakeholders disagreed with the uniform application of a $/MW value.	ISP Consumer Panel, EGA, Energetic Communities VBN, BSL, Climate council, COTA Tasmania, Darach Energy Consulting Services, Etrog Consulting, QEUN, EnergyAustralia, Shell, Transgrid, Star of the South, ECA, John Diesendorf, CEIG, Monash Digital Energy Future, QCC, Wanda Grabowski, AusNet, Hunter Job Alliance, Joy Duncan, MacKay Conservation Group, Moyne Shire Council. AEMO's Advisory Council on Social Licence continue to engage on these elements, supporting AEMO's ongoing consideration of social licence in planning activities, particularly the 2024 ISP[7].

[7] Minutes from Advisory Council on Social Licence meetings are available at AEMO's website via https://aemo.com.au/consultations/industry-forums-and-working-groups/list-of-industry-forums-and-working-groups/social-licence-advisory-council.

Theme	Description	Submitter(s)
	▪ Many stakeholders wanted greater transparency around how this value was derived. • There were other recommendations regarding greater information sharing with consumer advocates and incorporating engagement with Traditional Owners.	
Transmission	• Stakeholders raised clarifications or sensitivities being needed on several cost aspects including system security service requirements and costs, generation, and transmission schedules, OPEX assumptions, undergrounding costs, connection and downstream network costs, projects on private land without commercial consent, and investment in larger upgrades to ensure future proofing of investments. • Stakeholders also raised a need to clarify the sub-regional nodal representations and impacts of a number of proposed upgrades. • Responses noted how a lot of these cost clarifications have been further included as part of the *Transmission Expansion Options Report*.	ISP Consumer Panel, Shell, CEC, APA, EGA, BSL, Climate council, COTA Tasmania, Darach Energy Consulting Services, Etrog Consulting, QEUN, Transgrid, FFI, Iberdrola, QEUN, Simon Bartlett, RE-Alliance, EVC, BZE, Powerlink, WWF, VFF
Hydrogen	• Several stakeholders questioned the high blending of hydrogen in the *Green Energy Exports* scenario. • Fugitive emissions from hydrogen production was raised as a concern, along with the cost of transporting energy via transmission vs hydrogen pipelines.	ISP Consumer Panel, BSL, Climate council, COTA Tasmania, Darach Energy Consulting Services, Etrog Consulting, QEUN, WWF, ENA, PIAC, CEC, FFI, QEUN, RE-Alliance, Energetic Communities, AGPA, TasNetworks, Friends of the Earth, CPA
Renewable energy zones	• Stakeholders suggested a number of clarifications such as alignment with state based REZ plans, use of the land-use penalty factors, inclusion of costs of state-based benefit payment schemes, updates to offshore wind resource limit assumptions, review of non-REZ capacity factors and improvements to REZ transmission limit and resource limits transparency.	Origin Energy, FFI, Star of the South, AusNet, RE-Alliance, Friends of the Earth, ISP Consumer Panel, Windlab
Other	• Other topics, including report scope, gas system assumptions, financial parameters, fuel assumptions and employment factors. • Discount rates – feedback on the appropriateness of the discount rate, that the proposed discount rates are lower that current interest rates faced by developers, and noting there is insufficient evidence that the proposed discount rate reflects the discount rate required by private investors in the NEM. • Gas price forecast – submission highlighted the importance of an updated gas price forecasts as one of the most significant assumptions in the ISP.	AGPA, Ausgrid, BSL, Climate council, COTA Tasmania, Darach Energy Consulting Services, Etrog Consulting, QEUN, CEC, CPA, Energetic Communities, ECA, ENA, EnergyAustralia, FFI, Iberdrola, ISP Consumer Panel, PIAC, RE-Alliance, Simon Bartlett, TasNetworks, VBN

Note: additional feedback regarding consumer costs and integrated energy planning was also received, and will be considered in broader consideration of the ISP's role and scope, as appropriate.

2 Feedback and changes to scenarios and sensitivities

The 2023 IASR's set of scenarios and sensitivities was one of the most common topics among submissions.

The Draft 2023 IASR proposed four scenarios, and in response to feedback AEMO has reduced this to three for the 2023 IASR. This reduction improves the distinction between scenarios, and enables greater consideration for complementary sensitivity analysis to test specific settings and key uncertain assumptions considered of high value to AEMO and stakeholders.

Submissions also provided feedback on the scope of the IASR and ISP. As this was often integrated with feedback on the scenarios, it is included in this section.

2.1 Scenario design and scope feedback

Consultation questions that prompted feedback in Draft 2023 IASR

- Does the Draft 2023 IASR scenario collection adequately enable AEMO to sufficiently test the risks of over-and under-investment in the power system in the *Integrated System Plan*?
- Do the scenario names provide improved clarity regarding their drivers and potential use?
- Are the scenarios plausible and internally consistent?

Feedback received	AEMO response
Regarding scenario plausibility: **ACF** considered that the *Green Energy Exports* scenario is implausible, especially with high electrification, hydrogen and biomethane. They outlined that the assumptions did not consider appliance swapping costs, and gas network costs. They considered it highly improbable that hydrogen will replace gas in distribution pipelines. **ACF** also noted that the *Green Energy Exports* scenario should include broad renewable energy exports, low-emissions technologies and other energy-intensive products such as green steel. Furthermore, it should support a stronger domestic economy without relying on green gas and offsets.	AEMO has reconsidered the amount of hydrogen blending in the gas distribution network. For the *Green Energy Exports* scenario, the 2023 IASR now features a maximum rate of 10% by volume. AEMO notes that the scenario includes stronger economic growth as well as broader renewable energy exports than just hydrogen, including green steel and ammonia, as described in the scenario narrative.
Regarding scenario design: **CWC** submitted suggestions on scenarios including: • 1.5° scenario without assumptions of major exports includes high rates of electrification and energy efficiency. • Explore different technologies, assumptions around firming for electricity system, including consideration of a wider range of alternatives to gas peaking. • Explore different levels of decentralised energy, how this would influence transmission requirements and timing. • Explore impact of variation in energy, demand management, including energy efficiency, short-term demand response and load management.	AEMO's set of scenarios and sensitivities now includes: • A *Rapid Decarbonisation* sensitivity which is a 1.5˚C compatible sensitivity without substantial hydrogen exports. It adopts the high rates of electrification and energy efficiency from the *Step Change* scenario. • An exploration of a different level of decentralised energy, via the *Low CER Orchestration* sensitivity. • Consideration of varying levels of energy efficiency via the *Low Energy Efficiency* sensitivity. • Exploration of varying levels of demand response and load management – AEMO refer to this as Demand Side Participation, and it is defined at various levels for each of the scenarios Different firming technologies are an outcome of the ISP.

Feedback received	AEMO response
• Investigate future of gas demand and gas network assets, which was not within the scope of the multi-sector modelling conducted by CSIRO and CWC.	Exploring the future of gas demand, and gas network assets is currently outside the scope of the IASR and ISP, but AEMO will consider the thin the ongoing work to define the scope of future ISPs.

2.2 Sensitivities in the 2024 ISP

Sensitivities are deployed to test key areas of assumption uncertainty or influences on investments needs, and/or to provide deeper insights on specific areas of interest. AEMO received stakeholder feedback regarding the role and breadth of sensitivity analysis that will be deployed in the 2024 ISP. The 2023 IASR includes more content on sensitivity analysis than was proposed in the Draft 2023 IASR. Further sensitivity analysis may be identified to support the Draft 2024 ISP's insights. AEMO will report on these in the Draft 2024 ISP, with likely focus on parameters that are most relevant and impactful to the determination of the Optimal Development Path (ODP).

Consultation questions that prompted feedback in Draft 2023 IASR

- Do you consider any of the proposed sensitivities is not sufficiently relevant to be investigated in the 2024 ISP?
- Do you consider any additional sensitivities ought to be explored in the 2024 ISP?

Feedback received	AEMO response
Regarding re-using sensitivity themes from one ISP and IASR to another: **Ausgrid** recommended consistency in the sensitivities across IASR publications, citing the benefits of: • Clear, consistent communication with stakeholders and reduces overall forecast production and development costs. • Supporting similar broad themes to be tested against various network architecture and voltage levels. **Ausgrid** noted that *Strong Electrification* appeared to have been dropped as a sensitivity test and replaced with the *Hydrogen Export* scenario. Ausgrid noted that despite similar decarbonisation glide paths, they have wide variation of impacts at different network voltage levels, especially in terms of transmission vs distribution investment requirements.	AEMO agrees with the value of consistent communication and notes its adoption of a previous ISP Consumer Panel recommendation that every second IASR be a revision of the previous release. The retention of AEMO's 2021 IASR scenario names is an example of this intent, for scenarios that retain reasonable proximity to themes from the previous IASR. The *Rapid Decarbonisation* sensitivity is comparable to the previous *Strong Electrification*.
Regarding social licence sensitivity suggestions: **Energetic Communities** recommended that AEMO should "establish jurisdictional level resources for consumer advocates to participate throughout the ISP process, perhaps along the lines of network customer councils with sitting fees". Energetic Communities recommended that AEMO run a sensitivity where 50% of developments are cancelled due to social licence. Energetic Communities commented that it found the explanation of the social licence sensitivity confusing. **Star of the South** agreed with AEMO's considerations and recommended the implementation of the proposed $0.27 million/ MW increase in land use penalty factor. The submission encouraged AEMO to consider adding a sensitivity where transmission costs and timelines are increased substantially to reflect difficulty in approving and developing projects due to community constraints. The submission reasoned that this could be a "worst case scenario" to help understand some of the challenges the NEM may face over the coming decade without it being implemented into the base case.	AEMO notes Energetic Communities' submission and is considering a range of options for evaluating the impact of social licence. AEMO does not consider that applying a 50% cancellation sensitivity is meaningful because the ISP model would simply pick a different collection of projects. AEMO is engaging with its Advisory Council on Social Licence to tailor a sensitivity that explores impacts and risks relating to low social licence. Transgrid's suggestion on financially weighing social licence costs is already taken into account in AEMO's cost estimates. Most transmission cost estimates in the ISP have a wide (±50%) error margin, which is a class 5b estimate. This accuracy range allows the TNSP, during its preparatory activities and regulatory investment for transmission (RIT-T) process, to account for the additional costs due to social licence as the project scope is refined.

Feedback received	AEMO response
Transgrid supported AEMO considering social licence within an additional sensitivity analysis. The submission encouraged AEMO to provide a clear and transparent method to assess social licence issues, particularly for transmission expansion analysis. For example, AEMO could clearly set out how it would financially weigh up efforts to address a social licence issue through a longer transmission route against the associated increased project costs of a longer route. This would provide a valuable basis for TNSPs to consider social licence issues under consistent assumptions and approach as AEMO, for example within a RIT-T.	
Regarding the smooth infrastructure sensitivity: **FFI**, **TransGrid** and **CEC** were supportive of a smoothed infrastructure sensitivity (known as the *Constrained Supply Chains* sensitivity in the 2023 IASR), with the latter recommending it be modelled at an appropriate level of localisation (for example, by REZ), and account for projected local employment supply. **Origin Energy** stated that the usefulness of a smoothed infrastructure sensitivity which is intended to explore the costs and benefits of reducing the volatility of employment demand, was unclear. Origin Energy suggested that a more practical sensitivity might be to test a broader range of volatile factors, such as the supply chain issues.	AEMO acknowledges stakeholder support of the *Constrained Supply Chains* sensitivity. The *Constrained Supply Chains* sensitivity aims to explore the costs and benefits of reducing the volatility of infrastructure deliverability challenges, including the impact on employment demand and other employment factors, and recognising supply chain limitations as well. In that regard, it is consistent with Origin Energy's suggestions.
Powerlink proposed that AEMO should include a sensitivity for Pumped Hydro Energy Storage (PHES) meeting/not meeting AEMO's project assessment criteria	Pending insights observed in the modelling, AEMO may implement sensitivity analysis for projects of identified jurisdictional importance to improve the understanding of the effect of significant investments. AEMO has applied normal generation commitment criteria for both of the Queensland Energy and Jobs Plan (QEJP) PHES projects. As outlined in the 2023 IASR Assumptions Workbook, the Pioneer-Burdekin PHES project is yet to meet 'anticipated' project status, and therefore may be explored in sensitivity analysis.
Regarding an offshore wind sensitivity: • The **SEC** stated that the offshore wind sensitivity must include the New South Wales offshore wind priorities. • **RE-Alliance** supported AEMO considering the modelling of an offshore wind sensitivity, subject to further advice from the Victorian Government about offshore wind targets. Given the Victorian Government's ambition in this area, RE-Alliance considered that the 2022 ISP underplayed the potential scale of uptake of offshore wind. • **Transgrid** supported the inclusion of both fixed and floating offshore wind as eligible technologies, but did not consider it appropriate to include any specific offshore wind policies within the core scenarios until further regulatory and legislative changes provide greater certainty and detail. Until additional detail is provided, Transgrid supported AEMO's approach to limit inclusion of offshore wind policies to the offshore wind sensitivity.	AEMO considers that the Victorian Offshore Wind policy is intended to be legislated and is sufficiently developed to enable assessment of impacts on the power system, therefore AEMO will include the updated policy in all scenarios of the 2023-24 forecasting and planning activities. AEMO agrees with Transgrid that New South Wales' ambitions and targets are not sufficiently developed and as such will not be included.
Regarding supply chain cost and sensitivities: **Delta Electricity** recommended AEMO expand sensitivity analysis to include high impact risks such as supply chain constraints and labour shortages. The work should include analysis of the compounding of risks in these areas, as well as with respect to inter-related projects.	AEMO agrees on the importance of sensitivity analysis and welcomes Delta's suggestions on key potential sensitivities that may influence the development timing and need. AEMO has provided in the 2023 IASR further details on key sensitivities it will apply in the 2024 ISP and may consider other sensitivities as modelling demonstrates key assumptions and influences. As identified in the 2023 IASR, supply chain considerations are expected to be included in AEMO's sensitivity collection.
Regarding using sensitivity analysis to explore risks: **John Diesendorf** noted that the treatment of risk in the Draft 2023 IASR is not appropriate to the rapid transformation of energy sources for electricity. The four biggest risks are: • lack of sufficient skilled engineers and workers to deliver the plan, • failure to gain social licence for significant parts of the plan,	AEMO agrees that the stated areas represent significant risk to project delivery and has outlined that these areas will influence sensitivity analysis, as reported in the 2023 IASR. AEMO recognises that workforce, supply chain, social licence and delivery delays are risks that are well suited to sensitivity analysis, to demonstrate the robustness and resilience of candidate development paths.

Feedback received	AEMO response
• supply chain risks, and • failure of contractors to deliver major projects on schedule. **EnergyAustralia** also noted that there are risks in project execution, which are reflective of a combination of increasing costs (for example, to accommodate undergrounding, landowner compensation and suboptimal locations), and risks of commissioning delays.	
Regarding the role of 'combined sensitivities': The **ISP Consumer Panel** recommended that a small number of combined sensitivities be completed given the crucial importance of social licence in the Optimal Development Path (ODP), for example, the sensitivity of a candidate development path (CDP) to both date of full commissioning and capital cost. The ISP Consumer Panel noted that when the 2022 ISP Consumer Panel discussed combined sensitivities, AEMO stated that the modelling was not possible.	AEMO acknowledges the submission on combined sensitivities and may consider grouping sensitivities during the ISP's modelling stages. While it may be possible to combine some areas of input uncertainty, doing so may increase the complexity of understanding and interpreting the outcomes. Feasibility and specifics of the sensitivities will be determined when testing the robustness of CDPs during the ISP.
Regarding the use of sensitivity analysis to explore PV uptake uncertainty: **FFI** recommended a PV-related sensitivity where tariffs are restructured such that rooftop PV owners need to pay their fair share of connection fees or disconnect from the grid and face the full cost of storage.	AEMO notes that tariff structures are only one of many drivers affecting PV uptake, and as such there is insufficient value in conducting a sensitivity on this driver alone. AEMO considers the differing levels of PV across scenarios sufficiently reflects a range of drivers, including potential tariff changes.
Regarding the 2021 *Strong Electrification* sensitivity to explore faster decarbonisation: **CPA** noted that a *Strong Electrification* sensitivity was included in the 2021 IASR, and should again be included in the 2023 IASR. **WWF** agreed, and sought a significant focus on planning implications of a future that is a high ambition, high electrification and high energy efficiency option. **CEC** supported a similar theme, noting that electrification is more easily accessible and cheaper solution than hydrogen. A number of consumer organisations including **BSL, Climate council, COTA Tasmania, Darach Energy Consulting Services**, **Etrog Consulting**, and **QEUN** noted that residential electrification was emerging as a reality, and urged AEMO to understand how this trend might allow Australia to align with 1.5°C. **ACF** also recommended that AEMO complete a strong electrification sensitivity to model the impact of delays in transmission build across the scenarios. **ACF** further recommended that AEMO analyse the risk and impact of underinvestment, and consequent delays to transmission build, in achieving Australia's decarbonisation targets.	A wide range of options were assessed in the development of the scenarios and sensitivities. AEMO considers the intent of the listed submissions is addressed by the *Rapid Decarbonisation* sensitivity. Further details on this sensitivity are provided in Section 2.4 of the 2023 IASR. AEMO recognises the role and importance of residential electrification, with this component being a key influence on residential load growth across the scenarios. AEMO recognises the value of exploring the impact of delays in infrastructure developments, including transmission, and anticipates exploring this via sensitivity work covering supply chains and social licence. The impact that infrastructure delays may have on the effectiveness and efficiency of achieving the carbon budgets for each scenario may be apparent, however AEMO's modelling approach would allow adaptation from a delay, resulting in an investment response, at least in the electricity sector, to still operate within the NEM carbon budgets defined for each scenario.

3 Feedback and changes to inputs and assumptions

3.1 Public policy settings

AEMO received stakeholder feedback regarding public policies, the principles behind their inclusion or exclusion, and the method of modelling them in the 2024 ISP. The 2023 IASR clarifies these and expanded the list of policies that were discussed in the Draft 2023 IASR.

For the 2023 IASR, AEMO considered environmental and energy policies with reference to the 'public policy clause'[8]. The public policy clause allows AEMO to consider a current environmental or energy policy of a participating jurisdiction where that policy has been sufficiently developed to enable AEMO to identify the impacts of it on the power system and at least one of several other criteria is also satisfied. The criteria most relevant for the purposes of the 2023 IASR are enactment of the policy in legislation and a material funding allocation to the policy in a budget of a participating jurisdiction.

On 19 May 2023, Energy Ministers agreed to amendments to the national electricity laws to incorporate an emissions reduction objective into the National Electricity Objective (NEO)[9]. Currently, it is expected that the amendments will pass through South Australian parliament in September 2023, and AEMO will apply the new emissions objective to the ISP two months from commencement.

The emissions objective is presently proposed, subject to stakeholder consultation, to be complemented by a requirement that the Australian Energy Market Commission (AEMC) prepare and maintain a list of participating jurisdictions' targets, that contribute, or are likely to contribute to reducing Australia's greenhouse gas emissions – with the list of those targets being stated in a 'targets statement' to provide transparency to the regulated community. These targets must, at a minimum, be considered by AEMO in applying the objective to the ISP[10]. The public policy clause is included in the Commonwealth's rule change proposal currently under consultation by the AEMC[11], identifying rules for harmonisation with the new objective. The rule change will consider whether policies considered by AEMO in determining power system needs should include targets in the AEMC's 'targets statement'[12].

In identifying policies that may be included in the 2024 ISP, AEMO has, in consultation with each jurisdiction, included those policies that currently meet the public policy clause or are expected to satisfy the clause, or be included in the AEMC's targets statement, before the delivery of the 2024 ISP. These policies are relevant to the

[8] NER 5.22.3(b).

[9] See https://www.energy.gov.au/government-priorities/energy-and-climate-change-ministerial-council/working-groups/national-energy-transformation-partnership/incorporating-emissions-reduction-objective-national-energy-objectives.

[10] Information Paper, *Incorporating an emissions reduction objective into the national energy objectives*, May 2023, p8, at https://www.energy.gov.au/sites/default/files/2023-06/Incorporating%20an%20emissions%20reduction%20objective%20into%20the%20national%20energy%20objectives%20-%20Information%20Paper.pdf.

[11] Rule change proposal available on the AEMC's website at https://www.aemc.gov.au/rule-changes/harmonising-electricity-network-planning-and-investment-rules-and-aer-guidelines-updated-energy.

[12] NER 5.22.3(a) defines the power system needs relevant to the ISP, while NER 5.22.3(b), the public policy clause, defines the policies AEMO may consider in determining power system needs.

energy transition, and will impact Australia's emissions reduction objectives, particularly for the energy sector. Should a policy not meet the public policy clause, or not be included in the AEMC's targets statement, prior to delivery of the 2024 ISP, that policy will be removed as a modelling input/assumption. Instead, sensitivity testing may be used in the 2024 ISP to show the impact of including that policy at a later date.

Consultation questions that prompted feedback in Draft 2023 IASR

- Do you have any further views on the individual policies and their proposed application?
- Do you have any further views on the individual policies and their proposed application?
- Do you consider any additional policies missing that you consider important to include in some or all the scenarios? If so, please provide details.

Policy settings and policy inclusion criteria were popular submission topics. Individual feedback is outlined below.

Feedback received	AEMO response
Regarding consideration of broader policies that are under development by jurisdictions: **Community Power Agency, RE-Alliance,** and **WWF** all noted that additional policies are sufficiently advanced, budgeted, or on the path to legislation that they should be considered as included in the policy collection. The policy collection should extend to include jurisdictional emissions reduction targets, the Capacity Investment Scheme and the Federal Government's 82% renewable energy commitments. **RE-Alliance** recognised that it may be difficult for AEMO to model some of these scenarios, as there may be very little detail on how some of these targets will be met/have only recently been released. **Energetic Communities** noted that regulatory ambitions of jurisdictions are likely to increase, so the ISP development process needs to maintain a high level of agility to ensure its relevance. **AusNet** noted the Federal Government's proposal to incorporate emissions reduction as a new component in the national electricity objective (NEO) and the national gas objective (NGO). This includes any government public commitments that are directly related to (or likely to contribute to) emission reduction, including policies that are not legislated. Urgent consideration should be given as to whether the current public policy criteria set out in NER 5.22.3(b) are consistent with the Federal Government's emission reduction proposal. This includes whether the public policy criteria should include public commitments made by jurisdictional governments as matters of policy, worthy of inclusion in AEMO's optimisation models.	AEMO supports the changes to incorporate emissions reduction into the NEO, agrees with the need to appropriately consider all relevant policies that support the energy transition, and notes the significant number of policies that have been announced across jurisdictions since the publication of the 2022 ISP. The 2023 IASR now clarifies that where demonstratable pathways to legislation or budgeted funding mechanisms exist, policies that are under development and are in-progress to meeting the 'public policy criteria' will be included in the policy collection in the ISP. AEMO has consulted with each jurisdiction to identify relevant policies that currently meet the public policy clause or are expected to satisfy the clause before the delivery of the 2024 ISP. All relevant policies under this approach are described in the 2023 IASR (see Section 3.1).
Regarding State-based emissions reduction policies: **CitiPower**, **Powercor**, and **United Energy** noted that the Victorian Government's carbon emissions reduction targets of 75-80% below 2005 levels by 2035 and net-zero by 2045 should be met in all AEMO's proposed scenarios. **FFI** also noted that state-based emissions targets are key policy items and decisions have already occurred, at least partially, on the basis of the emissions targets. If the states are making decisions influenced by these targets, then they should be modelled.	AEMO has consulted with each jurisdiction to identify relevant policies that currently meet the public policy clause or are expected to satisfy the clause before the delivery of the 2024 ISP. All relevant policies under this approach are described in the 2023 IASR, particularly Section 3.1.2 which outlines the relevant federal and state energy policies, including the Victorian emissions reduction targets. (see Section 3.1).
Regarding the inclusion of offshore wind policies:	Since the publication of the Draft 2023 IASR, AEMO now considers that the Victorian Offshore Wind policy is sufficiently advanced for inclusion within the scenario's policy collection. Therefore, AEMO will consider this

Feedback received	AEMO response
Origin Energy noted AEMO's proposal to model the Victorian Government Offshore Wind targets as a sensitivity as it is subject to legislative changes. **Friends of the Earth** commented that in its view, AEMO has inadequately represented announced and legislated government policies. Friends of the Earth recommended that AEMO include several polices across all of its scenarios, including: • Victoria's Rolling Offshore Wind Targets. • Formal declaration of the Gippsland Offshore Wind Zone. • Commonwealth *Offshore Electricity Infrastructure Act*. • Candidate offshore wind zones in New South Wales, at the Hunter and Illawarra. **CEC** noted that offshore wind remains only a sensitivity and will not be included in the ISP as it is not yet legislated. CEC encouraged AEMO to be sufficiently prepared to include it should this status change.	policy to be part of the core scenarios. The policy collection that meets the NER 5.22.3(b) requirements, and considering the effect of the pending NEO amendment to include emissions reduction, is described in detail in the 2023 IASR (see Section 3.1).
Regarding policy transparency needs in the 2023 IASR: The **ISP Consumer Panel** suggested that the final 2023 IASR include table/description of polices and that they are checked against AEMO policy inclusion criteria and 'cut-off date' for policy considerations. Further, AEMO should require strong evidence base before adopting assumptions/inputs based on policy alone.	The 2023 IASR provides detail on the policies included in the ISP. It is accompanied by the 2023 IASR Assumptions Workbook, which provides quantitative descriptions of the policies and the method of their implementation. It may be prudent to consider whether additional policy developments meet the public policy clause when consulting on the Draft 2024 ISP, and prior to finalising the 2024 ISP. AEMO has actively engaged with jurisdictions to ensure all relevant policies have been included that already meet, or will meet, the public policy criteria and that have sufficient details to enable modelling consideration.

3.2 Social licence

Social licence is another key consideration for the energy transition. 'Social licence' is a term commonly used to refer to local community acceptance of new infrastructure development. The efficient and effective transition of the energy sector will rely on both government and the energy industry understanding and delivering the community's ambition and needs for the future power system, both broadly in the community, and in the places that host new development.

AEMO has established an Advisory Council on Social Licence to assist in understanding social licence issues facing the energy transition, for consideration in developing the ISP[13].

In the Draft 2023 IASR, AEMO stated that social licence could be a theme of the scenario collection and/or be applied as sensitivity analyses to the scenarios.

Consultation questions that prompted feedback in Draft 2023 IASR

- Do you have specific feedback on the quantification of social licence in the development of REZs?
- How should AEMO incorporate social licence in the assessment of transmission, generation, and/or storage projects?

[13] Further information about the Advisory Council on Social Licence is available at https://aemo.com.au/consultations/industry-forums-and-working-groups/list-of-industry-forums-and-working-groups/social-licence-advisory-council.

Many of the stakeholder submissions commented on social licence issues; individual feedback is outlined below.

Feedback received	AEMO response
Regarding stakeholder support for social licence sensitivity analysis: **Origin** recommended AEMO consider social licence and its potential to result in transmission build delays. **AusNet** suggested there may be more meaningful reforms to embed social licence like excluding options based on TNSP preliminary land use constraint analysis. **CEIG** also supported the development of a social licence-related sensitivity in the ISP.	AEMO recognises the need for alternative assumptions to be explored relating to social licence, potentially reflecting greater development limitations and higher cost to address social licence issues could also be considered. AEMO is considering a range of options to evaluate the impact of low social licence, including a sensitivity for transmission development delays. AEMO is also engaging with its Advisory Council on Social Licence to tailor a sensitivity that explores impacts and risks relating to low social licence overall.
Regarding the timeliness of social licence: **FFI** suggested that different scenarios may have different appetites for social acceptance. FFI suggested that proposed projects will be more likely to gain social licence in the near term. On this basis, FFI reasoned that it would be good to preference the development of proposed projects first. **Hunter Jobs Alliance** put forward that the 2024 ISP must begin to tackle social licence in a more substantive fashion as transmission and generation projects increasingly come to new areas. **Joy Duncan** considered that there would be a raft of cost-effective initiatives that would support and enhance social licence. **MacKay Conservation Group**, **QCC** and **Wanda Grabowski** suggested that AEMO take more responsibility for building social licence of renewable energy. From these submissions' perspective, this includes coordinating national strategic land use planning, and increasing the breadth of representation on the Advisory Council on Social Licence.	AEMO agrees with **FFI** suggestions about the importance of social acceptance and will consider projects consistent with their development status as part of the ISP modelling. This includes incorporating preparatory activities requested from TNSPs for future ISP projects, including requests for outcomes of community consultation. AEMO acknowledges the need for increasing consideration of social licence, establishing its Advisory Council on Social Licence to support further consideration of it in AEMO's planning activities. Although AEMO is not responsible in its National Transmission Planner function for ultimate design, location or route selection, or delivery of transmission projects in the NEM, AEMO is endeavouring to provide more detail on its own processes and provide greater certainty to interested parties.
Regarding the types of social licence that should be considered: The **ISP Consumer Panel** recommended that AEMO: • Expand Draft 2023 IASR definition to include "consumer social licence". • Expand model sensitivities to cover schedule delay, increased capex resulting from the need to obtain social licence. The Panel suggested two varieties of social licence for AEMO's consideration: • Community social licence, which relates to measures including engagement of impacted communities and payments to landowners for hosting electricity infrastructure. • Consumer social licence, which relates to acceptance of the costs to all consumers of the generation and network infrastructure. The Panel expressed that absence of the first adds to cost and schedule delay while absence of the second reduces consumer support for the ISP. **EGA** suggested that AEMO should seek to understand where existing industry and other uses with potential off-site impacts are, and ensure current zoning appropriately protects operators and surrounding communities. **QCC** recommended that AEMO improve planning, community engagement and benefit sharing arrangements across the NEM.	The IASR does not differentiate between community and consumer social licence at this stage. AEMO will continue to work with its Advisory Council on Social Licence on related topics while developing the Draft 2024 ISP. The proposed social licence sensitivity analysis in the Draft 2024 ISP will explore the impacts and risks relating to low social licence, for example through considering the impact of transmission development delays, increased costs, or consideration of other relevant variables. Note that the current approach to infrastructure development already includes community consultation by the TNSPs.
Regarding the social licence cost factors:	The land use penalty factor is a value calibrated within the ISP model to represent a cost penalty for adding more renewable generation in a REZ beyond the REZ's resource limit up to its land use limit. The value helps

Feedback received	AEMO response
EGA highlighted that, in its view, social licence is not about acceptance, but rather that it is comprised of three components: legitimacy, credibility, and trust. EGA expressed concern that consideration of social licence is being viewed as an economic consideration to buy social licence (such as is implied by the proposed land use penalty factor). EGA would prefer the use of tools such as strategic land use assessment and a multi-criteria analysis. The **ISP Consumer Panel** noted that it understood the proposed social licence cost factor ($0.27m/MW) reflected a consumer price index (CPI) approach, that didn't consider detailed land cost studies or surveys. **RE-Alliance** also questioned how the land-use penalty cost factors have been derived and sought clarity on whether (in New South Wales) the introduction of the Strategic Benefits Payments Scheme was considered. The **ISP Consumer Panel** also questioned whether such a value could be common across all REZs. **AusNet** also considered that they did not support the current uniform approach across all REZs. **Moyne Shire Council** suggested that a strategic land use planning approach which manages cumulative impacts is needed to stop further clusters and mitigate future impacts. The **ISP Consumer Panel** also questioned whether other factors, such as supply chains, may lead to cost impacts, such that cost estimates are considerably underestimated. **AusNet** otherwise supported quantifying additional transmission augmentation and generator connection costs provided the IASR acknowledge their limited level of accuracy. They considered that these costs should not be relied upon when quantifying net-benefits within the ISP or RIT-T. **Hunter Jobs Alliance** suggested that the costs should include costs of engagement with traditional owners. **QCC** recommended that AEMO improve compensation across the NEM.	the ISP model select the point at which it may be more cost effective to choose to plant generation in alternative REZs in the model. CPI escalation has been applied in this IASR to allow this ISP calibration value to move proportionately with other escalated values in the ISP cost benefit analysis. AEMO recognises that the land use penalty factor is not based on detailed land cost studies. During the ISP modelling, AEMO will consider whether there is significant assumption uncertainty about the land use penalty factor, and potentially deploy sensitivity analysis if needed to explore its impact. Landholder benefit payments such as the New South Wales strategic benefits scheme are included as separate costs in the ISP modelling, distinct from the land use penalty factor. As noted in Section 3.1.3 of the 2023 IASR, AEMO will include transmission land payment programs that are considered committed (in New South Wales, Victoria and Queensland) in the ISP analysis. AEMO acknowledges that the breadth of preliminary land use analysis from TNSPs may increase in future, as it is a step already undertaken as part of preparatory activities. AEMO will likewise evaluate other uncertain assumptions it considers to be of material impact to the ISP's outcomes through sensitivity analysis, and has identified a *Constrained Supply Chains* sensitivity, for example. AEMO recognises the three core components outlined by EGA as important aspects of social licence. AEMO notes the suggestions from Moyne Shire Council and QCC, but has not considered them within the scope of this 2023 IASR consultation. AEMO recognises the importance of social licence and ensuring high levels of engagement with Traditional Owners. AEMO has engaged with the Advisory Council on Social Licence on this topic and AEMO acknowledges the importance of incorporating First Nations land use consideration into a high-level plan, as well as the challenges. Consideration will be given on how to highlight the benefits of Traditional Owner engagement in the ISP.

3.3 Emissions and climate assumptions

Stakeholders submitted on a range of topics regarding emissions, carbon costs and sequestration.

Feedback received	AEMO response
Regarding alignment to international emission scenarios: **Energetic Communities** submitted that it is unclear how AEMO scenarios have been aligned to the IEA's WEO and queried the extent which ISP scenarios reflect the WEO scenarios. It also stated that all scenarios assume the emission reduction stipulated in the CCA is at least achieved and use offsets to do so and stated an interest in minimising offsets to 5% of targets.	Each of AEMO's scenarios was mapped to a WEO target, and feeds into IASR inputs in a variety of ways. For example, as discussed in Section 2.2.7 of the multi-sector modelling report[14], the limits and uptake rates on electrification and efficiency across different sectors were largely based on comparative analysis between scenarios from the WEO. Scenarios are also aligned on long-term temperature outcomes, as discussed in the IASR.
Regarding consideration of NEO reforms on system costs: **CEC** recognised that reform to the NEO means that the cost of carbon emissions must now be formally accounted for by regulatory decision makers and can no longer be a false	The AER's Cost Benefit Analysis Guidelines set out the classes of net market benefits that must be considered in the ISP. The guidelines do not currently include the cost of emissions as an existing market benefit class. However, AEMO's ISP Methodology consultation likewise acknowledged the need to consider inclusion of a value of carbon

[14] At https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2022/2023-inputs-assumptions-and-scenarios-consultation/supporting-materials-for-2023/csiro-climateworks-centre-2022-multisector-modelling-report.pdf?la=en.

Feedback received	AEMO response
externality. AEMO must therefore carefully assess all of its scenarios, inputs and assumptions, to ensure that they accurately account for the full suite of carbon costs.	emissions if a suitable value were established. See the ISP Methodology[15] for more information.
Regarding emissions sequestration: Several stakeholders suggested that the scale and reliance on sequestration was unrealistic, including **Harry Adus**, **Joy Duncan**, **FFI, Iberdrola.** **Iberdrola** also noted that given concerns around the credibility of many offset schemes currently available, ISP should include a scenario with a much lower use of carbon sequestration. **BZE** noted that modelling carbon offsetting is unclear on the levels of sequestration achieved by land-based sequestration versus process-based sequestration. **FFI** noted that development of direct air capture (DAC) in scenarios other than the *Green Energy Exports* scenario (where there will actually be a driver for it to be developed).	Emission sequestration within each of the scenarios is derived within the multi-sector modelling performed by CSIRO and CWC and is subject to a constrained cost curve implementation. As discussed in Section 2.2.6 of the multi-sector modelling report, there are three types of sequestration: carbon forestry, DAC and carbon capture and storage (CCS). Land-based sequestration in particular uses inputs aligned to the Federal Government's *Australia's Long-Term Emissions Reduction Plan,* in turn derived from the Land-Use Trade-offs (LUTO) model. No scenario incorporates the use of international offsets. The maximum amount of land sequestration in the scenarios takes place in *Green Energy Exports*, where it reaches approximately 130 metric tonnes carbon dioxide equivalent ($MTCO_2e$) by the 2030s. Utilisation of all decarbonisation options will be an important method for Australia to reach net zero emissions economy-wide. AEMO does not consider it appropriate to limit deployment of sequestration, but recognises that measures to validate the scale and reliability of these solutions is a role in the management of Australia's overall emissions in future. AEMO considers that the set of scenarios and sensitivities, which needs to be balanced to test a sufficiently broad and distinct number of assumptions, explores the role for various decarbonisation activities, including energy efficiency, electrification, direct offsets and alternative fuel use across sectors. AEMO provides further discussion on the separate role and evolution of land-use sequestration and process-based CCS in the 2023 IASR. DAC assumptions allow DAC technology deployment beginning in the late 2030s across most scenarios. The *Green Energy Exports* scenario commences early deployment of DAC from 2025 consistent with the scenario's theme of rapid technological development. Once deployed, the model optimises DAC's use, balancing its cost with alternative emission reduction options.

3.4 Consumption and demand historical and forecasting components

Two submissions covered a range of forecast components and are covered here rather than within the subsections for each component.

Feedback received	AEMO response
Regarding the quality of inputs to the forecasting process: **Shell** sought reviews of consultants' economic forecasts, cost of new supply side resources, electric vehicle (EV) uptake and charging forecasts. **Simon Bartlett** noted that AEMO's data and assumptions appear to be based on a range of technical, economic, and political projections of the future, with little calibration with actuals. An example is basing the projections of the future CO_2 emission caps on aggressive political targets vs Australia's actual total emissions. It was suggested that a sensitivity study could include varying the CO_2 caps as they	Several processes exist to review and improve forecast accuracy, and is an influence on scope and consultant procurement strategies. These include: • For new supply side resources, the *GenCost 2022-23 Final report* referenced in the Draft 2023 IASR contains an assessment of how previous cost estimates for large-scale technologies compare with current estimates (see Figure 2-1 in the *GenCost 2022-23 Final report*). • For the economic forecast, AEMO's annual Forecast Accuracy Reports[16] cover that, comparing actual growth with the forecast for the most recent year. • For new technologies like EVs, getting "actuals" data to compare with is difficult, and AEMO has in its 2022 Forecasting Improvement Plan[17]

[15] See https://aemo.com.au/en/consultations/current-and-closed-consultations/consultation-on-updates-to-the-isp-methodology.

[16] At https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/forecasting-and-reliability/forecasting-accuracy-reporting.

[17] See https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2022/2022-forecast-improvement-plan-consultation/2022-forecast-accuracy-report-final.pdf.

Feedback received	AEMO response
appear to have a huge impact on the modelled future development paths.	listed that it is monitoring for suitable data sources for such technologies, and will – when sufficiently good data is available – start assessing accuracy of these too in the Forecast Accuracy Report. Generally, AEMO endeavours to align the forecasts for components with recent actuals where available (noting that this can be difficult for some items). For example, the Oxford Economics Australia (OEA, formerly known as BIS Oxford Economics) forecasts use actuals as published by the Australian Bureau of Statistics as the foundation of the forecast and the final report includes a comparison with State Treasury forecasts along with some forecast accuracy metrics. Significant new policy in recent years has been introduced by various governments to encourage emissions reduction. The uncertainty on the trajectory and breadth of investments to address emissions reduction objectives in these policies is a key dimension within each scenario, as is outlined in the 2023 IASR, and has influenced the sensitivity collection as well. AEMO will consult stakeholders on its Forecast Accuracy Report methodology in the second half of 2023 and will appreciate feedback on improvement opportunities.

3.4.1 Historical demand data

The following feedback was received in response to the *Historical demand data* section of the Draft 2023 IASR.

Feedback received	AEMO response
Regarding forecast relative to historical demand: **Powerlink** noted an observed disconnect between actuals and the near-term forecast, both in terms of magnitude and the average load shapes.	AEMO has investigated this and finds it could be a demand definition mismatch between the actuals and reference year traces plotted in the submission. AEMO gets a closer alignment when plotting the series for operational sent out demand (consistent with the published ESOO traces). AEMO is aware that users of the forecast in some cases require the load shape (as provided through AEMO's load traces) in addition to energy and minimum/maximum demand forecasts. AEMO does publish an assessment of monthly maximum demand values from the load traces as part of its annual Forecast Accuracy Report, which assesses the reasonableness of the seasonality of the load traces. Powerlink's submission has illustrated a figure that could be used to show the reasonableness of the daily shape of the load traces. AEMO will consider if Powerlink's illustration can be used in future reports to illustrate changes to daily load shapes over time.

3.4.2 Historical weather data

Consultation questions that prompted feedback in Draft 2023 IASR

- Do you consider the use of the listed weather stations appropriate to forecast consumption and maximum/minimum demand?

In response to the consultation question above and the topic in general, stakeholders submitted this feedback.

Feedback received	AEMO response
Regarding the modelling of weather sensitive demand: **TasNetworks** expressed its support for using the proposed Hobart weather station to forecast Tasmania demand. **Energetic Communities** stated that climate change was not taken into account in AEMO's modelling and a single weather station is not representative of weather systems affecting an entire state.	AEMO notes TasNetworks support. AEMO incorporates climate change into its minimum and maximum demand forecast as well as its annual consumption forecast. More information is in AEMO's Forecasting Approach – Electricity Demand Forecasting Methodology, A2.3 Climate Change. Minimum and maximum demand forecasts utilise a top-down approach. Using a single weather station is sufficient to forecast regional maximum demand by seasons, with testing proving that it yields similar outcomes to using multiple weather stations. A single weather station is used for temperature outcomes only, and weather dependent generation (such as rooftop PV) is accounted for through much more granular data AEMO gets from its consultants. For temperature, AEMO acknowledges use of multiple weather stations could be of value in explaining forecasting outcomes, and potentially for subregional forecasting. The latter relies on being able to accurately cluster the half-hourly regional demand by weather stations. AEMO continues to look for improvements to its forecasts, and, and when such have been identified and verified, will propose them when consulting on the Electricity Demand Forecasting Methodology or its Forecasting Improvement Plan. For the 2024 ISP, AEMO will explore adaptations to historical weather conditions to increase the frequency of weather extremes, as a means to simulate potential growth in weather extremes affecting electricity demands and/or renewable generation. This is intended to increase the understanding of the resilience of the investments to potential changes to climate within a primarily renewable energy power system.

3.4.3 Distributed photovoltaics (PV)

Consultation questions that prompted feedback in Draft 2023 IASR

- Are the assumptions which are proposed to apply affecting CER (including PVNSG) investments providing a reasonable spread of futures to evaluate the transmission-scale investments needed for the energy transition?
- Should other considerations affecting the operation and orchestration of consumer resources be considered, particularly regarding the variation between the *Diverse Step Change* and *Orchestrated Step Change* scenarios? Will these assumptions effectively distinguish the investment needs of transmission-scale infrastructure with greater or lesser consumer resources?

In response to the consultation questions above and the topic in general, stakeholders submitted this feedback.

Feedback received	AEMO response
Regarding factors acting for and against growth in PV systems: **RE-Alliance** noted AEMO's forecast of approximately 50% of all dwellings having PV systems installed by 2050, and wonders whether this forecast is both too low and too slow. The **ISP Consumer Panel** submitted that the uptake of rooftop PV is constrained by the growing rental market (expected to be 33% in 2024), which is a tenure type characterised low PV uptake rates. **RE-Alliance** recognised that there are barriers to all residences installing solar PV such as shading, residential flat dwellers having less roof space, landlord/tenant issues, and also recognised that there are a range of potential solutions to some of these issues.	Owner-occupied houses (a prime candidate for PV installation) currently have around 35% PV uptake, and in 2050 that increases to between 70% and 90% across scenarios. The forecasts recognise the lower penetration of PV in rented dwellings, the changing proportion of rented dwellings over time, and the potential for alternative financial models to increase uptake in detached rented dwellings. The above does not assume an unrealistic proportion of rooftop owners choosing to install solar panels, with the IASR report noting the life of a solar panel is long (25-30 years) relative to housing stock turnover (median 10 years in New South Wales). In other words, the rooftop owners that do choose solar panels have, over time, a broader impact than their current homes. This effect also, over time, helps PV installations benefit tenants of rented properties.

Feedback received	AEMO response
FFI noted that achieving renewable energy production appears to rely heavily on an assumption distributed PV will almost double leading up to 2030. Its submission went on to note that as penetration rates in some suburbs are already reaching 70%, expecting doubling PV might be interpreted more as a hope and less as a plan. **FFI** argued the ISP should have options to deliver on this policy should the CER PV not eventuate. **RE-Alliance** noted that government has set aside funding of $102.2 million over four years in the 2022-23 Budget for the Community Solar Banks initiative.	Regarding physical characteristics of dwellings, shading is a considered as a limiting factor in uptake. The forecasts also recognise the increasing opportunity for PV installations to occur on other dwelling types, such as townhouses, terraces, and to a lesser extent apartments. Accounting for the above considerations arrives at the overall proportion of dwellings noted by RE-Alliance. As PV uptake is far from uniform across suburbs, the fact that some suburbs already have high uptake rates is not a material barrier to ongoing growth. Additionally, other considerations provide support for the forecast growth, such as larger-than-original end of life replacements, larger system sizes and population growth. Previous work has recognised that the contribution of PV to the energy system operation is maximised through the use of orchestration. The *Low CER Orchestration* sensitivity is designed to test the needs of the system in the event of lower levels of orchestration As noted in the submission, while solar banks would be theoretically owned by renters or apartment dwellers, AEMO's CER forecasts would classify them as PVNSG rather than rooftop PV.
Regarding the consultant choice for the PV forecasts: **Hydro Tasmania** noted that AEMO proposed to use only GEM's forecast for distributed PV under the *Green Energy Exports* scenario and stated that CSIRO has also accounted for the assumptions underpinning the scenario in developing its forecasts.	AEMO's CER forecast was developed from two consultants (CSIRO and GEM), who used independent approaches to modelling CER uptake. The blending method that AEMO chose supports the objective of using multiple scenarios to get reasonable upper/lower bounds. Specifically, the *Green Energy Exports* scenario represents an optimistic scenario, which aligns most closely with GEM's projections.
Regarding network implications of CER: **FFI** submitted that: • Distributed PV forecasts appear to be driven by current uptake trends without considering likely thresholds. • Hosting capacity of the distribution network is increasingly being identified as a constraint. • Cost of upgrading the hosting capacity distribution system should be considered as part of the overall planning process. • Distributed battery forecasts have been reduced based on evidence that previous forecasts were too ambitious- still notably over-forecast. • CER and battery assumption could affect the modelling of generation requirement and transmission investment-over built PV and storage at the cost of consumers.	AEMO has worked with DNSPs to understand the potential for PV hosting. The IASR notes a combined position recognising that DNSPs are actively planning and moving to execution of a range of CER enablement initiatives. EVs and distributed batteries are likely to serve as solar soaks, and, where coordinated by virtual power plants (VPPs), offer a valuable resource for the consumers and the NEM.
Regarding biomass as CER: **VBN** noted that the forecast mapping of CER by various 'expert' bodies (Table 14) omits energy from biomass technologies. Further, the near total omission of biomass to energy including from the carbon sequestration land sector means most of the assumptions and inputs in the report need to be reassessed and revised.	Table 14 of the Draft 2023 IASR focuses on PV and battery technologies. Behind-the-meter biomass technologies are captured in AEMO's Other Non-Scheduled Generation forecast, along with technologies like small-scale wind and hydro, generation from waste coal mine gas, and industrial co-generation using natural gas as fuel. The Other Non-Scheduled Generation forecast covers a wide range of technologies. This forecast generation is netted off the demand, so in the ISP any biomass based generation from sites less than 30 MW is reflected as a demand reduction rather than as modelled supply. In the *Step Change* scenario, it includes some growth in the biomass component of the forecast, though not substantial based on AEMO's awareness of current investment interest across surveyed industrial consumers. In the *Green Energy Exports* scenario, more substantial growth has been assumed, in particular from biomass.

3.4.4 Electrification of sectors other than transport

Consultation questions that prompted feedback in Draft 2023 IASR

- Do you consider the approach to applying electrification to the load shape of residential and business consumers as reasonable?

In response to the consultation question above and the topic of electrification (excluding transport) in general, stakeholders submitted feedback as follows.

Feedback received	AEMO response
Regarding the minimum scale of electrification: **Powerlink** suggested moderating NEM electrification, including the transportation sector, in the *Progressive Change* scenario **VBN** said that it is fallacious to assume that electrification is a key part of the best pathway to achieving reduction of greenhouse gas emissions.	Considering the scale of new policy supporting electrification, including transportation, since the 2022 ISP, AEMO considers the scenario appropriately explores the downside risk. *Progressive Change* features 38% (30 TWh) reduced electrification compared to *Step Change* in 2040. This figure includes 23 TWh from the transportation sector. AEMO considers the scenario appropriately tests a reasonable lower bound. The 2023 IASR now includes an additional *Electrification Alternatives* sensitivity to explore the impacts of greater potential bioenergy use across the energy mix. However as forecast in the Draft 2023 IASR, informed by the CSIRO and CWC multi-sector modelling, electrification is forecast to provide a reasonably significant contribution, including from transportation, residential and commercial sectors. This new sensitivity recognises in particular that some high heat industrial processes that use a diverse mx of fuels may retain a molecular feedstock in future, more than was originally included in the *Step Change* scenario.
Regarding the costs and barriers associated with electrification: **Shell Energy**, **APA**, and **ENA** said AEMO should consider costs to households of switching gas appliances to electricity. **ENA** noted technical barriers to electrification such as heritage listing and where the space required for heat pumps is larger than existing gas appliances. The **ISP Consumer Panel** stated that overall the multi-sector modelling seems overly simplistic approach to a very complex issue, with little relevance to the decisions that industrial users make in real life. **APA** commented that cost savings associated with electrification usually overlook the significant cost of electricity infrastructure upgrades and the cost of new transmission and generation. **APA** said that the cost of augmentation (including at distribution level) will push up network charges. **APA** drew attention to consumer willingness to convert from gas to electricity and the extent to which cost reductions or other incentives influence consumer choices.	Capital costs for electrification (such as replacing gas stoves with induction) were considered in the multi-sector modelling. AEMO acknowledges that technical barriers to electrification exist under certain conditions and may be a limiting factor for some dwelling and building types. More detailed bottom-up modelling of building stock would be required to incorporate these potential limits, however despite this AEMO considers the range of electrification rates between scenarios to be a reasonable reflection of the pace and breadth of electrification. Rather than a detailed bottom-up forecast of all dwellings/appliance types across the energy sector, the forecast is by assumptions regarding the maximum total share of technically feasible electrification over time at a detailed sub-sectoral level. This is complemented with annual build rate constraints by technology and sub-sector. The annual build rate values are sourced from research underpinning the Australia Industry Energy Transitions Initiative's (ETI's), '*Pathways to industrial decarbonisation – Phase 3 technical report*'[18], which represents the latest information available for Australian industry at the time of the multi-sector modelling consultancy. ETI is supported by ARENA and project partners include a broad representation from large industrial companies. AEMO's annual large industrial load survey process also is used to calibrate and influence the industrial load forecast, particularly in the near term. This increases consideration of information provided by participants, including plans for electrifying processes, when developing electricity consumption forecasts. To examine the risks of electrification uncertainty, the *Electrification Alternatives* scenario is designed to recognise challenges industrial customers may face regarding electrification. It explores the role of biomethane as an additional decarbonisation option for industrial customers.

[18] ClimateWorks Centre and CSIRO 2023, *Pathways to industrial decarbonisation: Phase 3 technical report*, Australian Industry Energy Transitions Initiative, ClimateWorks Centre, at https://energytransitionsinitiative.org/wp-content/uploads/2023/02/Pathways-to-industrial-decarbonisation-phase-3-technical-report-February-2023-Australian-Industry-ETI.pdf.

Feedback received	AEMO response
	AEMO acknowledges that the bottom-up costs associated with distribution augmentations to cater for fuel-switching from gas to electricity use are not itemised in the multi-sectoral forecasting outputs, and optimising these investments is currently outside the scope of the ISP.
Regarding the pace of forecast electrification: **CitiPower**, **Powercor**, and **United Energy** jointly said that the reduction in electrification forecasts for the two *Step Change* scenarios compared to its 2022 *Step Change* scenario appears inconsistent with the likelihood and magnitude of government policy further supporting electrification. **EnergyAustralia** considered that AEMO's starting point assumptions for electrification overestimate what is achievable.	*Step Change* shows a slight reduction compared to the 2022 *Step Change* forecast, primarily due to lower industrial electrification forecasts, informed by work on the Australian Industry Energy Transitions Initiative (ETI). The ETI evaluated the readiness for commercial deployment of various electrification technologies and electrification costs relative to other decarbonisation options. For example, it suggests that electric boilers in alumina refining and battery electric trucks in mining will only be readily deployed from the 2030s. Regarding the starting point, where possible AEMO validates input assumptions with industry data and may modify various components where that validation suggests that the pace of change is slower than that forecast. In the final 2023 IASR, the electrification forecasts for residential and commercial sectors have been modified to account for a slower pace of fuel switching modelled in the 2023 GSOO. This recalibration reflects AEMO's observation (through analysis of metering data) that suggested limited electrification of these sectors to date. In the case of the EV forecasts, AEMO uses vehicle sales data from the latest quarterly VFACTS report to scale the forecasts over a four-year period from the latest actuals date.
Regarding whether the forecast appropriately is capturing electrification potential: **ElectraNet** suggested that electrification in South Australia could substantially exceed the levels considered in the Draft IASR and occur faster. **ElectraNet** also recommended that AEMO review the demand forecasts with reference to the Department of Climate Change, Energy, the Environment and Water's Australian Energy Statistics (AES).	AEMO's electrification forecasts takes into consideration the results of multi-sector modelling combined with information gathered from TNSPs and DNSPs on an annual basis. AEMO follows a 'committed' criteria for incorporating new loads in the consumption forecasts, but may examine more prospective load growth using sensitivities. Refer to Section 2.1 of the methodology for further information. Since the publication of the Draft 2023 IASR, AEMO has further engaged with ElectraNet, including reviewing material in ElectraNet's updated 2023 Transmission Annual Planning Report (TAPR). For the 2024 ISP, AEMO will examine potential events that may increase, or reduce, the need for transmission investments. For example, connection of significant load growth opportunities for new industrial, mining and manufacturing loads in regional South Australia may need transmission investment to support efficient and effective operations. AEMO will explore whether such an event – that is, the potential commitment of significant new loads beyond the core scenarios' growth and electrification forecasts – would support alternative development preferences.
Regarding the transparency of forecast fuel-switching: **Iberdrola** stated that AEMO should: • Publish the percentage of potential electrification that is modelled in each year, for each of the scenarios. • Publish the percentage of Victorian residential gas use that is being electrified year on year. **Iberdrola** and **FFI** noted that the shape of newly electrified loads will not necessarily mirror existing electricity consumption profiles, particularly in relation to electrification of residential gas, and that business load would also have some level of seasonality to its load shape.	AEMO publishes electricity and gas consumption data at https://forecasting.aemo.com.au, and the electrification forecasts are available in the 2023 IASR Assumptions Workbook. This information can be used to estimate electrification rates for each scenario. AEMO will consider what additional information may be available in future releases. For the 2024 ISP, AEMO will be using the approach listed in the Draft 2023 IASR to calculate the time of day impacts of electrification on electricity demand profiles (that is, to use a flat profile for business consumption, and to use a seasonal shape of Tariff V gas consumption for residential consumption, with its daily shape consistent with the existing electricity consumption). While small commercial gas load does exhibit some seasonality, it is not as significant as residential loads, and AEMO considers that the seasonality of the business sector would be less material when combined with other industrial loads. This is observable when examining existing gas loads across a larger cohort (that is, Tariff D), which shows less significant seasonality. AEMO will continue to seek additional information over time on the likely load shape of electrified loads.

3.4.5 Electrification of the transport sector

Consultation questions that prompted feedback in Draft 2023 IASR

- Do you consider the methods and assumptions described in this section regarding transport electrification are reasonable and provide appropriately for each scenario?
- Do you consider the change in vehicle charging load profiles is more appropriate than the 2021 IASR profiles given they are developed from trial data, particularly for the reduced peak demand from 'convenience' charging?
- Should other factors regarding electrification be considered that may impact the consumer electricity load shape?

Feedback received	AEMO response
Regarding cost-reflective pricing's influence on EV charging: The **ISP Consumer Panel** and **Shell** suggested the use of cost-reflective and EV charging pricing in modelling EV outcomes.	The forecasts incorporate cost-reflective pricing. Consumer adoption and response to various tariffs are reflected in the mix of charging profiles: 1. Day, Night, and vehicle-to-home (V2H) profiles are designed to reflect theoretical and practical response to time of use (ToU) tariffs 2. The vehicle-to-grid (V2G) and VPP profiles are designed to reflect coordinated charging assumptions, which are a form of response to price signals that could relate to factors such as network congestion and weather-driven demand.
Regarding fuel efficiency standards: **RE-Alliance** submitted that the scenarios should include modelling of fuel standards, across the scenarios, or at least in the *Progressive Change* scenario, while **EVC**'s submission reflected differing understanding of fuel efficiency standards inclusion. **CEC and Shell** submitted that the scenarios should include modelling of fuel standards, across the scenarios, or at least in the *Progressive Change* scenario. **EVC** claimed that the EV uptake outlook appears too strong. If rapid implementation of robust and ambitious fuel efficiency standards for light vehicles at a federal level is not achieved, the levels of EV uptake noted in these low-end forecasts is unlikely to be realised.	While the Federal Government has commenced a consultation process on consideration of fuel efficiency standards[19], it is unclear what outcome or specific requirements of future vehicle standards will apply in Australia upon its conclusion. It is premature to explicitly account for these potential standards, however the scenarios AEMO has developed include material change to the vehicle fleet, particularly transitioning to electric alternatives to existing internal combustion engine (ICE) vehicles. AEMO considers that the potential emergence of fuel standards will be one of many factors leading to the higher and lower outlooks for EV uptake that AEMO has developed across the scenarios. Two scenarios (*Step Change* and *Green Energy Exports*) consider aggressive uptakes of EVs which is consistent with the expected outcome of fuel standards. In contrast, the *Progressive Change* scenario narrative reflects, by design, supply chain disruptions and higher technology costs.
Regarding passenger vehicle type forecasts: Regarding the split between Battery Electric Vehicles (BEVs) and Plug-in Hybrid Electric Vehicles (PHEVs), **EVC** commented that it does not expect the percentage of PHEVs in the fleet to look so low and suggested review of European markets.	AEMO's forecasts indicate a decreasing proportion of PHEV in the fleet. Although PHEVs are currently a popular option, fundamentally PHEVs' greater complexity is either less profitable to produce, and/or more expensive to purchase for vehicles that are capable of full-electric configurations. Furthermore, BEVs have more attractive operational (fuel/maintenance) costs and upfront costs (after inclusion of incentives and rebates). Thus, AEMO sees the relative attractiveness of BEVs and PHEVs changing over time, shifting away from the early adopter trends that embraced PHEV as more BEV vehicles become available. AEMO has noted, and corrected, a PHEV forecasting error in the Draft 2023 IASR. Correction of the error has the effect of increasing the proportion of PHEV vehicles. However, that effect is modest and the above insight regarding the PHEV outlooks still holds true.
Regarding alternatives to electrified transportation: **VBN** suggested that the assumption that internal combustion engines (ICE) must be replaced by electricity and batteries for all personal, freight, and public transportation is false. The use	Considering the insights provided by CSIRO in its EV forecasts that support this IASR, AEMO expects that BEVs will be the dominant zero emissions transport technology in consumer vehicles due to their relative affordability and simplicity. However, AEMO acknowledges that EVs are not the exclusive alternative to ICE, and some alternatives remain, such

[19] See https://www.infrastructure.gov.au/sites/default/files/documents/consultation_paper_-_australias_fuel_efficiency_standard.pdf.

Feedback received	AEMO response
of renewable gas and liquid transportation fuels is likely to increase, as witnessed in Sweden, Finland, and other countries.	as lower or zero emissions vehicles that utilise renewable gas. Hydrogen may be utilised for freight transportation (rigid and articulated trucks), while biofuels may be valuable in sectors such as aviation which generally do not have an electric alternative, as reflected in the multi-sector modelling report[20]. AEMO will continue to monitor the value and applications of emerging fuel sources in Australia, including biofuels. For example, AEMO's *Electrification Alternatives* sensitivity explores the use of biomethane as a fuel source for decarbonisation of industry.
Regarding hydrogen vehicle numbers: **ACF** suggested a reduction in the number of hydrogen vehicles, especially for light vehicles and buses.	AEMO sees fuel cell EVs (FCEVs) as most likely to see uptake in heavy duty applications, rather than the light vehicle market. such as for articulated trucks. AEMO forecasts that in 2050, hydrogen buses will represent 5% of the fleet, and hydrogen light vehicles will represent 1%, in most scenarios, which are relatively small shares. Hydrogen fuelled articulated trucks however are forecast to represent a much higher percentage (70% for articulated trucks and 5% for rigid trucks) due to the relative difficulties and costs of electric alternatives. For these vehicles, AEMO is satisfied that a higher relative proportion is also appropriate.
Regarding heavy vehicle charging: **FFI** suggested that trucks and buses (which are heavily in use during daylight hours for both business and passenger purposes) appears incompatible with daytime charging.	AEMO mostly agrees with FFI's observation in the short term, however, sees this potentially changing in the medium to long term and incorporates additional charging options for these vehicles. In the 2023 IASR, AEMO anticipates that in the short term, the charging profile for trucks and buses will be dominated by the convenience profile (70-80%), which generally corresponds to the night charging profile, with only 4-15% of charge occurring during the day. In the long term, AEMO expects the proportion of day charging may increase as trucks and buses seek low cost recharging options during the solar peak hours. This may be achieved via operational and technological means, with faster recharging solutions, battery swaps if feasible, active charging during driver breaks and loading/unloading times among other options. Non-daytime charging will continue to represent a material contribution to heavy vehicle charging irrespective. The scale of energy required for charging these vehicles is 500 GWh, so a relatively small proportion (2%) of the overall electricity consumption.
Regarding the change in forecast charge profiles since the 2021 IASR: **CitiPower, Powercor, and United Energy** submitted that it is unreasonable for the evening convenience EV charging profile halving in the Draft 2023 IASR compared to the 2022 ISP. Although the 2023 IASR profiles were influenced by Australian trials, early adopters' charging patterns may not reflect mass-market adoption and new construction, multiple EV ownership, and government rebates/funding are projected to boost dedicated higher-power chargers at home. This increase in home charging equipment may increase evening EV charging in future. **EVC** also found that typical contribution per EV at home at time of the evening peak was consistently on the order of 250W/vehicle, as distinct from the ~600W/vehicle figure referenced in the Draft 2023 IASR Workbook.	The 2023 IASR's convenience profile's evening peak is around 37% higher than the day peak. This compares to the 2021 IASR's convenience profile with an evening peak of 72% higher than the day peak. While the 2023 IASR evening to day peak is smaller, AEMO still considers it a clear signal of the popularity of evening charging. AEMO 2023 figures stem from recent trial data revealing that specialised high-power chargers are less popular than previously thought. In the absence of additional evidence, AEMO believes that the updated evening peak figures reflect the higher upfront costs for dedicated chargers and their installation, the fraction of homeowners who will eventually opt for high power chargers, and the likelihood that future EVs use smart charging by default. Combined, these factors support a reduction in expected evening peaks for convenience charging. The figure of 250 W per vehicle relates to the charging profiles from the Origin Energy and the Energy Queensland trials. However, AEMO found that this data showed charging patterns that responded to time-of-use (ToU) price signals and pre-determined patterns. Responding to price signals and pre-planned charging patterns correspond to Smart daytime and Smart night-time charging profiles (which AEMO see as becoming increasingly popular), and so AEMO has used this data for those charging profiles. AEMO considers it is less suitable for estimating the convenience charging profile.

[20] See Section 4.6.5 of Multi-sector energy modelling 2022 report, at https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2022/2023-inputs-assumptions-and-scenarios-consultation/supporting-materials-for-2023/csiro-climateworks-centre-2022-multisector-modelling-report.pdf?la=en.

Feedback received	AEMO response
	CSIRO identified UK trial data as being representative of convenience charging behaviour, as its load profile centred around times of immediate benefit to the customer, such as when they returned home from work in the early evening. AEMO agrees with CSIRO's assessment and notes that the associated recharging load is 600 W per vehicle.
Regarding the lower end of the EV forecast: **EVC** queried AEMO's lower end of the EV forecast range relative to the August 2022 ESOO, with the new minimum estimate being in the range of 1.5 million as opposed to 615,000 for 2030-31.	EVs are experiencing extremely high rates of growth, as is expected during a technology's early period of consumer adoption. Challenges in forecasting, such as lags in actual sales data, revisions to sales data, and random under/over variations are particularly impactful during the early periods of consumer adoption. This is because small deviations tend to bring forward/put back the steepest rate of increase, which disproportionally affects the short-term forecasts. In contrast, early deviations have a much lower impact on later time periods, as the rate of growth slows due to progressive saturation of the market. AEMO notes that the June 2022 sales data used for the Draft 2023 IASR forecast was significantly higher than the March 2022 sales data used for the 2022 ESOO, which brings forward the steep part of the adoption curve. Recent EV sales data has continued to exceed prior forecasts. Government policy, and its timing, has been the largest single driver of the deviations. Due to the timing of policy announcements, some state policies and objectives were not considered in the 2021 IASR. For instance, the Victorian government set a goal for 50% of light vehicle sales being zero emission vehicles (battery and FCEVs), with subsidies for 20,000 vehicles available from July 2021. While the policy announcement timing missed the 2021 IASR, the policy accelerated the adoption of EVs, bringing forward the steepest portion of the adoption curve. The announcement for South Australia and Queensland to achieve 100% sales by 2035 and 2036 respectively also came after the 2021 IASR.
Regarding technical road limits affecting vehicle uptake: **FFI** mentioned the Australian road legislation limit on the front axle load, and without a notable breakthrough in technology, this will severely limit the size and/or range of battery-electric trucks in Australia. This could change consumption in 2030 by around 6 TWh in the *Green Energy Exports* scenario.	AEMO considers it too early to apply the front axle load limit as a perpetually binding constraint, as technical and operational solutions are likely to evolve. In rigid vehicles, for example, the cargo area is merged with the truck, indicating the potential for some sacrifice of cargo space for the battery.
Regarding the appropriate scale of EVs as active consumer energy resources: **FFI** suggested that vehicle ownership and use indicate that energy conservation is unlikely to be a primary motivator. Even if there is sufficient automation, evidence suggests that humans want the ability to override the systems and do not want to interact with the electricity grid, but they do want to interact with their devices and appliances on their terms.	AEMO acknowledges that currently available EV usage data (real-world and trial) may not perfectly indicate longer-term behaviour. AEMO has sought EV data from stakeholders throughout the forecast development, and it is understood that the data used is the best currently available. AEMO does not assume that EV users prioritise energy related concerns over other matters requiring transportation. The currently available data is the net result of all the energy and non-energy factors driving user behaviour. To the extent FFI's submission relates to V2G and/or V2H charging profiles, AEMO notes that the forecast values in the year 2040 (for example) are only approximately 2% of the EV fleet. AEMO agrees that the vast majority of vehicle owners will expect to retain their vehicles as vehicles, rather than home-energy-management devices, hence the relatively low proportion. AEMO considers its scenarios explore a suitably wide range of results given the uncertainty.

3.4.6 Fuel-switching and alternative gas production

Stakeholders submitted feedback as follows.

Feedback received	AEMO response
Regarding overall levels of hydrogen: • **FFI** called for an expanded vision for hydrogen, increasing production above levels assumed in the Draft 2023 IASR, noting that in the 2022 ISP, the *Hydrogen Superpower* scenario was viewed most useful by a material portion of	There was a wide diversity of feedback on appropriate levels of hydrogen in the scenarios generally. The IASR needs to balance diverse viewpoints as to technical and commercial feasibility. Considering hydrogen development at significant scale is a key uncertainty, AEMO considers it appropriate to have a wide spread of

Feedback received	AEMO response
Delphi Panel respondents. This view was supported by **ENA**, which stated that the use of renewable hydrogen was being unnecessarily constrained in three of the four scenarios. • In contrast, TasNetworks called for a more moderate uptake of hydrogen, while the **ISP Consumer Panel** and **PIAC** called for lower levels of hydrogen across the board.	hydrogen futures across the scenarios. AEMO recognises that progress is occurring on some projects in the near-term, hence the near-term forecasts are greater than those in the 2021 IASR outlooks, reflective early pilot developments and government support (for example, the inclusion of the South Australian Hydrogen Jobs Plan). Investment risks and needs in both the near-term and long-term will be reasonably examined in AEMO's opinion with this scenario and sensitivity collection. It should be noted that the assumed levels of hydrogen in the 2023 IASR reflect only the grid-connected portion; a substantial amount of off-grid electrolysers may be developed.
Regarding the level of hydrogen blending in the distribution network: **PIAC**, **Energetic Communities**, **WWF**, **CEC**, **CPA, ISP Consumer Panel, Iberdrola** and **Friends of the Earth** expressed concern regarding the assumed potential levels of hydrogen in the gas distribution network. This applies particularly to the *Green Energy Exports* scenario, which the Draft 2023 IASR described as having up to 100% hydrogen blending. Blending of hydrogen was described as either implausible, unsafe, or not energy or cost efficient. **Iberdrola** also questioned why there were different levels of blending assumed across the scenarios. Conversely, **ENA** supported higher levels of hydrogen blending, noting a previous study finding that use of hydrogen for home heating would be significantly cheaper than electrification.	AEMO notes the range of feedback regarding hydrogen blending in the gas distribution network. Recognising the potential cost implications to appliances and other devices of high hydrogen blends, and in response to stakeholder feedback, AEMO has reduced the ceiling of hydrogen blending in the gas distribution network from 100% to 10% (by volume) for the *Green Energy Exports* scenario. This change harmonises the assumptions across all scenarios regarding hydrogen blending and reduces the scale of residential and commercial hydrogen use in *Green Energy Exports*. For industrial customers, direct hydrogen supply options are assumed to be available, avoiding the delivery of hydrogen within distribution networks. This allows more overall domestic hydrogen usage across all sectors in *Green Energy Exports* than other scenarios. AEMO has also developed the *Electrification Alternatives* sensitivity, which assumes increased blending of biomethane into the gas distribution network, along with hydrogen.
Regarding hydrogen production technologies: **BZE**, **PIAC** and **WWF** proposed that hydrogen from steam methane reforming (SMR), as a non-renewable form of hydrogen production, should not be considered, particularly in the *Green Energy Exports* scenario. The **CEC** submitted that autothermal reforming (ATR) is increasingly becoming cost-competitive with SMR at scale, and that it has stronger carbon capture potential. ATR also operates at higher process efficiency than SMR.	AEMO has considered this feedback and agrees that SMR may be inconsistent with the decarbonisation objectives of the scenarios. While future investment in SMR may occur, AEMO considers that the ISP modelling would be improved with concentration on green hydrogen options for domestic and international use. For the purposes of the 2023 IASR, AEMO has categorised ATR similarly with SMR.
PIAC, **Energetic Communities**, **CPA** and **Friends of the Earth** recommended that AEMO consider potential fugitive hydrogen emissions.	AEMO considers that the scale of greenhouse gas emissions from hydrogen generated from renewable energy is, at most, minor compared to the reduction in emissions due to replacing fossil fuels[21], and that fugitive emissions of hydrogen production is not expected to be impactful to the investment needs of the power system.
Regarding the cost of equipment and infrastructure upgrades that will impact hydrogen adoption: **Energetic Communities** and **RE-Alliance** noted that the cost of network and equipment upgrades for use of hydrogen are not modelled. **ENA** noted that the cost to upgrade the electricity network and electrical appliances are not modelled.	Upgrade costs were not specifically considered in the multi-sector modelling for either gas or electricity distribution networks, due to lack of publicly available cost data. Such costs may form part of future IASRs, however outcomes from a range of studies have been considered when setting the scenario parameters. AEMO considers that, with the refinements to the scenario and sensitivity collection, the range of hydrogen, biomethane and electrification levels represent an appropriate assessment framework for infrastructure investment needs.
Regarding other necessary inputs for hydrogen electrolysis: **QEUN** noted requirements associated with green hydrogen production including water availability, low-cost electricity, electrolyser equipment and scarce minerals. QEUN noted that the Draft 2023 IASR is silent about these inputs and assumptions.	Inputs and assumptions used in modelling for green hydrogen are detailed in the multi-sector modelling report (for example, see comments on water in Section 3.12). The commercial viability of green hydrogen is a foundational assumption for the *Green Energy Exports* scenario; the scenario itself explores a future of cost and technological breakthroughs to enable ubiquitous hydrogen availability.

[21] See https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1067144/atmospheric-implications-of-increased-hydrogen-use.pdf.

Feedback received	AEMO response
	Assuming strong technological progress in the *Green Energy Exports* scenario in this regard, AEMO likewise assumes that other inputs to electrolysers, including scarce minerals, are also available at low, or lessening, cost.
Regarding biomethane and decarbonisation: BZE noted the use of biomethane is counter-productive to decarbonisation efforts, and that electrification and renewable hydrogen are preferable. ACF also suggested that biomethane does not satisfy the criteria under NER for a policy to be included in the ISP and requested clarification on how the scale of biomethane would be developed.	Each scenario includes assumptions around future technology and supply developments that apply in specific scenarios that provide an influence on future needs that are internally consistent with the scenario narratives, and extend beyond the policy settings. The *Green Energy Exports* scenario considers a plausible future where government or business support increases for biomethane. The *Electrification Alternatives* sensitivity explores the use of biomethane to reduce the emissions from molecular fuel. AEMO notes the purpose of scenarios and sensitivities is to support a range of analyses that enable robust planning of the power system. AEMO considers that the potential for biomethane development at scale is plausible, and that its associated uncertainty is appropriately explored by the breadth of scenarios and sensitivities.
Regarding biomethane potential: **VBN** and **AGPA** suggested that the potential for biogas and biomethane production is far greater than suggested in the Draft 2023 IASR **Hydro Tasmania** recommended AEMO should allow for the uptake of biomethane in the *Diverse Step Change* scenario, but not stipulate a specific target for its uptake.	The new *Electrification Alternatives* sensitivity includes the assumption of increasing biomethane supply replacing natural gas over time.
Regarding cost of transmission and hydrogen: The **ISP Consumer Panel** raised concerns regarding the cost to consumers of transmission needed for hydrogen exports, and the associated economic risks.	Hydrogen projects are included in the IASR to understand the impact the emergence of a hydrogen sector would have on the needs of the power system. The ISP will explore the extent to which transmission, storage and generation investments will differ in this scenario relative to others, which will be useful for stakeholders. The *Rapid Decarbonisation* sensitivity will also enable consideration of the investments needed without hydrogen developed at scale, but with strong decarbonisation objectives influencing the pace of transition. In this manner, the scenario and sensitivity collection will provide appropriate guidance on the investments and risks associated with hydrogen in the power system.
Regarding the inclusion of hydrogen policies: **TasNetworks** suggested that policies like the Tasmanian Government's Renewable Hydrogen Action Plan can be captured as an ISP sensitivity	AEMO notes the suggestion and will consider whether Tasmanian outcomes regarding hydrogen in the scenario collection and the modelling insights would benefit from sensitivity analysis as the modelling progresses for the 2024 ISP.

3.4.7 Economic and population, including connections

Four stakeholders submitted feedback about the economic, population and connections forecasts.

Feedback received	AEMO response
Regarding housing-related forecasts feeding into the IASR: **RE-Alliance** sought to clarify whether the household and connections forecasts include recent Government initiatives such as the National Housing Accord[22], which has committed to building one million new homes over five years from 2024. **ECA** submitted: • Evidence on population growth, dwelling stock growth changes, urban density, housing tenure trends should be further investigated by AEMO and notes their impacts on other inputs are critical, particularly from a demand and distributed generation perspective.	The dwellings forecasts (which underpin the connections model) were delivered by OEA in September 2022 and included all relevant Government initiatives in place at that time. As the National Housing Accord was announced later (October 2022) it was not explicitly included. However, the scenario forecasts are reasonably aligned with the intent of the Housing Accord and therefore it is not considered a material deviation to the current dwellings forecasts. AEMO agrees with ECA's comments that population and housing assumptions influence the outcome of demand forecasts. Regarding the dwellings growth, the compound annual growth rate provided in the 2022 multi-sector modelling report is the average growth rate over the outlook and not a constant growth rate applied each year. This simplified way of representing dwelling growth is not a replacement

[22] See https://ministers.treasury.gov.au/ministers/jim-chalmers-2022/media-releases/national-housing-accord-working-together-help-tackle.

Feedback received	AEMO response
• Concern about a constant rate of annual growth for dwellings, which is incompatible with population trends and forecasts. • Recommendations that AEMO investigates correlation between population growth and dwelling stock growth rates and come up with revised ranges for all scenarios (based on assumption that constant dwellings growth driven by constant population growth). **ECA** recommends that CSIRO's home ownership percentages should be revised down (with wider spread) to reflect societal trends (assumption influences ability to utilise CER).	for the dwellings forecasts provided by OEA. In the underlying dwellings forecast, variability in the annual growth rate over the forecast outlook is observed, including periods of downturn. Additionally, the population forecasts grow by a declining rate over the outlook (varying by scenario), consistent with the suggestion that the dwellings forecast be based on such a population forecast. Likewise, declining rates of home ownership have been captured by CSIRO, with *Step Change* reflecting the long-term historical trend apparent in ABS Census data, and *Progressive Change* and *Green Energy Exports* capturing the lower and upper bounds for the range of realistic possibilities. Home ownership rates are considered in forecast components where they are relevant, such as the PV forecasts.
Regarding economic conditions: **FFI** noted that a slower economy may result in reduced load growth (or higher costs) and that it is unlikely there will be a sustained surplus so any short-term surplus is probably negligible, and that a stronger economy may see increased growth and investment, including lower costs.	AEMO agrees, noting that the economic forecasts are applied in a manner that this relationship between economic growth and consumption growth plays out in the scenarios.
Regarding implications of the new Western Sydney Airport: **Transgrid** identified an emerging issue for new electricity consumption driven by developments around the new Western Sydney Airport. Currently, forecasting is not flexible enough to fully factor in the expected long-term increase in consumption driven by this development, which Transgrid forecasts as up to 1,000 MW of additional demand. Given this, Transgrid encourages AEMO to consider how to ensure developments like this are properly captured within long term forecasts to allow sufficient time for the network infrastructure upgrades to be planned and delivered.	AEMO's business mass market (BMM) forecasts are based on an econometric model that utilises OEA economic forecasts as a key driver. Due to the scale of the development, the economic uplift from the development of the area surrounding Western Sydney Airport would be captured in OEA forecasts for New South Wales. Correspondingly this results in AEMO forecasting increased commercial electricity consumption for the region.

3.4.8 Electric storage uptake and virtual power plant (VPP) aggregation

Consultation questions that prompted feedback in Draft 2023 IASR

- Are the assumptions which are proposed to apply affecting CER (including PVNSG) investments providing a reasonable spread of futures to evaluate the transmission-scale investments needed for the energy transition?
- Should other considerations affecting the operation and orchestration of consumer resources be considered, particularly regarding the variation between the *Diverse Step Change* scenarios? Will these assumptions effectively distinguish the investment needs of transmission-scale infrastructure with greater or lesser consumer resources?
- AEMO has adopted the average of each consultant's projections regarding battery and VPP orchestration levels from GEM and CSIRO for the *Diverse Step Change* scenario, which results in a higher uptake forecast than an alternative if adopting the lower forecast from CSIRO in isolation. Do stakeholders have any comments on the adoption of this level?

Feedback received	AEMO response
Regarding CER orchestration: **Hydro Tasmania** queried whether it may be prudent to retain a level of uniformity on the level of CER coordination across the scenarios.	AEMO's scenario narratives are designed to capture a range of potential energy futures. While a more uniform level of CER orchestration might be useful in isolating other specific drivers of change between scenarios, the level of CER orchestration is a key input to understanding downstream impacts such as minimum or maximum demand.

Feedback received	AEMO response
FFI queried whether there is a sufficient difference between the two *Step Change* scenarios, and notes that *Orchestrated Step Change* is not sufficiently more orchestrated than other scenarios to really define its own scenario space. **FFI** noted: • CER may grow without orchestration, noting that consumers won't want to give up freedom of control, and enforced orchestration may also act as a dampener on investment. • Current tariff structures mean that rooftop solar systems are outcompeting utility scale solar arrays on the basis of cost avoidance, which is unsustainable. • There is very little evidence of VPP uptake currently and battery uptake is slower than previously forecast.	AEMO has developed a *Low CER Orchestration* sensitivity to gain insights as to the impacts of alternative levels of orchestration. AEMO agrees with FFI's comment regarding the difference between scenarios, and has adapted the scenario collection, as outlined in the 2023 IASR. Recognising that VPP developments are in their infancy, AEMO is introducing a *Low CER Orchestration* sensitivity to explore the investment impacts if orchestration is significantly lower than that assumed in the scenarios.
Regarding engagement with DNSPs, and CER hosting: The **ISP Consumer Panel** sought detail on AEMO's level of engagement with DNSPs, including: • Ensuring IASR forecasts are aligned with DNSP forecasts. • Widening scope of engagement with DNSPs outside a purely technical focus. **BZE** put forward that distribution network upgrades will be critical to enabling electrification and better orchestration of CER technologies and recommended that AEMO expand its remit of the ISP to include distribution level modelling. **CEC** recommended that assumptions regarding the capacity of the distribution network to host additional volumes of rooftop PV need to be carefully assessed. In **CEC**'s view, consumer energy resources, distributed energy solutions are central to the transition. **CEC** highlighted that there is a complex interplay between uptake of these resources and volumes of utility-scale generation and storage.	AEMO engaged with DNSPs at numerous times throughout the 2023 IASR's development, including to assess alignment on CER forecasts. Specifically, AEMO collaborated directly with a DNSP-ISP working group, as well as at FRG meetings, industry meetings, and other direct discussions. While not all DNSP forecasts are updated at the same time due to different reporting requirements, AEMO notes close alignment on PV forecasts, while battery and EV forecasts are less uniformly aligned due to the relative immaturity of those technologies. AEMO also engages in joint planning with TNSPs to understand underlying distribution capacities at the transmission connection point. While distribution level modelling is outside the scope of the 2024 ISP, AEMO may incorporate an enhanced representation of distribution capacities in future ISPs as the scope of the ISP evolves.
Regarding distributed battery systems: **CEC** noted the importance of understanding the practicality of consumers installing large behind the meter battery storage systems.	The average installed residential battery capacity is assumed to grow from 10-15 kWh over the forecast horizon. This is small enough that there should not be any issues meeting the required standards for installation (for example, AS/NZS 5139) in most dwellings (for example, the battery energy storage system (BESS) can be installed against an external wall), noting that owner-occupied, detached houses comprise the vast majority of dwellings where battery uptake is expected.

3.4.9 Energy efficiency

Four stakeholders provided the feedback summarised below to the draft energy efficiency forecasts in the Draft 2023 IASR. These draft energy efficiency forecasts were based on CSIRO and CWC's multi-sector modelling. Since publication of the Draft IASR, AEMO has updated energy efficiency forecasts through consultancy with Strategy. Policy. Research (SPR) to increase the understanding of relevant energy efficiency policy influences and market-led energy efficiency savings likely to occur without policy intervention. Draft SPR forecasts were presented and discussed at the March FRG.

Feedback received	AEMO response
Regarding the approach to energy efficiency: **RE-Alliance** said it was encouraged by the high levels of energy efficiency policy ambition in the *Green Energy Exports* scenario. They also stated that a secondary step would be to advise government on the quantum of energy efficiency abatement required, along with potential measures to meet the forecast outcomes. **RE-Alliance** encouraged AEMO to model high, more ambitious, levels of energy efficiency policy and other policy measures in the *Green Energy Exports* scenario	The final 2023 IASR contains policy-based and market-led energy efficiency forecasts for the 2023 scenarios, in addition to a *Reduced Energy Efficiency* sensitivity modelled on existing policy measures. The 'gap' between the *Reduced Energy Efficiency* sensitivity and *Step Change* indicates the potential role of energy efficiency above existing policies. See the 2023 IASR for more details on this sensitivity. The *Green Energy Exports* scenario includes extensions of current policy to increase the use of key decarbonisation activities and investments, such as energy efficiency, biomethane and hydrogen deployment. A range of stakeholder views have been received on the scenario, and

Feedback received	AEMO response
FFI noted: • A "need" to increase energy efficiency is not a good foundation for a forecast and alternate emissions reduction options are available. • Emissions objectives do not appear to have changed from the *Hydrogen Superpower* scenario to the *Green Energy Exports* scenario. • Energy efficiency may be more important in the scenarios where the grid is 'dirtier' (as it would contribute more to emissions reductions).	overall AEMO considers that the changes made to it now reflect the best insights about that possible future. The Draft 2023 IASR energy efficiency forecasts considered a range of emissions reduction options, including fuel switching, to meet scenario-specific decarbonisation goals at the least-cost and also took account of NEM emissions. The final energy efficiency forecasts follow a lower trajectory in the short to medium term, compared to the draft, though the potential for savings is higher from 2050 onwards for the *Green Energy Exports* scenario, reflecting the introduction of hypothetical measures to align with the scenario narrative. Compared to 2021 *Hydrogen Superpower* scenario, the final forecasts for the *Green Energy Exports* scenario are lower because of policy changes (for example, National Construction Code 2022's whole-of-home budget encouraging electrification, which is considered negative electricity savings) and a significant reduction in GEMS/E3 forecast savings based on updated modelling by the Commonwealth Government. While stronger energy efficiency measures to reduce emissions in a 'dirtier' grid is a reasonable investment preference in that future, AEMO has considered that it is internally inconsistent to expect the highest investment by consumers in energy efficiency savings in the *Progressive Change* scenario, given the weaker economic outlook in that scenario.
Regarding assumptions and their transparency, and data currency: Energy consumer advocates raised the following points in their shared submission: • **QCC** said that energy efficiency assumptions should be more explicit for ease of understanding, that the update of the National Energy Performance Strategy should be included in the underlying energy efficiency assumptions, and that more ambitious energy efficiency scenarios should be explored. • **ECA** noted that the multi-sector modelling data is out of date. • **Energetic Communities** said that the modelling assumptions should reflect the technology uptake habits of consumers rather than choosing the lowest cost.	The Draft 2023 IASR supporting material includes a link to the CSIRO-CWC report which contains additional information on energy efficiency assumptions[23]. This modelling approach looks at the 'technical potential' of energy efficiency, so does not explicitly cover policies or strategies. The final energy efficiency forecasts developed by SPR[24] (to increase transparency of policy versus market-led drivers) consider existing policies that meet the criteria for inclusion, or hypothetical measures that fit in with the scenario narrative, in addition to market-led energy efficiency savings likely to occur without policy intervention. At the time of writing, the National Energy Performance Strategy[25] (NEPS), had not been finalised, however, SPR modelled hypothetical measures that would reflect the intent of NEPS to accelerate demand-side action. AEMO accepts that some multi-sector modelling inputs may have more recent updates, however the latest modelling includes stronger energy efficiency technologies for *Green Energy Exports*. AEMO notes Energetic Communities' points reflecting consumer choices. energy efficiency forecasts include policy-driven consumer behavioural changes that persist even after the policies end. The market-led energy efficiency savings would capture consumer behaviour.
Regarding energy efficiency program validation and inevitable market-led investments: **Energetic Communities** considered that AEMO should demonstrate how current jurisdictional energy efficiency programs compare with each of the scenarios' energy efficiency targets and should explore a scenario where energy efficiency outcomes do not eventuate. **Energetic Communities** also stated that transitioning to energy efficient housing should be considered in the same way as the electrification of transportation, drawing similarities between the scale of net-zero housing and its impact on the grid and that of EVs.	The 2023 IASR contains policy-based energy efficiency forecasts for the 2023 scenarios, in addition to a *Reduced Energy Efficiency* sensitivity modelled on existing policy measures only. This sensitivity would represent a scenario where energy efficiency outcomes beyond existing policy settings do not eventuate. The scenarios capture a range of outcomes relating to the pace and scale of energy efficiency savings. Additionally, the energy efficiency forecasts are not modelled on static policy settings but assume that existing policies would be adjusted in line with scenario narratives (as is transport electrification), as well as the introduction of hypothetical measures. For example, the National Construction Code is modelled to become more stringent over time (requiring higher star ratings). The 2023 IASR also includes market-led investments, as (like electrified transport) consumers

[23] At https://aemo.com.au/energy-systems/major-publications/integrated-system-plan-isp/2024-integrated-system-plan-isp/current-inputs-assumptions-and-scenarios.

[24] At https://aemo.com.au/energy-systems/major-publications/integrated-system-plan-isp/2024-integrated-system-plan-isp/current-inputs-assumptions-and-scenarios.

[25] Submissions on the National Energy Performance Strategy Consultation Paper were closed on 3 February 2023, after its release on 10 November 2022. More information available at https://www.energy.gov.au/government-priorities/australias-energy-strategies-and-frameworks/national-energy-performance-strategy.

Feedback received	AEMO response
	are likely to continue investing throughout the energy transition to reduce their energy needs.

3.4.10 Large industrial load forecasts

AEMO received one item of feedback regarding the large industrial load forecasts.

Feedback received	AEMO response
Regarding strong growth opportunities in South Australia being reflected in AEMO's planning: **ElectraNet** engaged with a range of proponents from the mining sector, hydrogen industry, data centres, processing facilities to connect to the transmission network. This could equate to an additional 1 GW of peak demand and 5 TWh of additional load by 2030.	AEMO requests information from TNSPs and DNSPs on an annual basis to improve the quality of AEMO's large industrial load (LIL) forecast, in particular by acting as a key source of information for ensuring that AEMO includes all known changes to large customer loads[26]. Loads that meet AEMO's 'committed' criteria are incorporated in the 'central' scenario in accordance with the Electricity Demand Forecasting Methodology Information Paper[27]. Other more prospective loads that meet a subset of the committed criteria may be considered for higher growth scenarios. AEMO has followed up with NSPs that have made submissions to the 2023 IASR in relation to new loads. AEMO also notes that many enquiring new loads may not eventuate, may be significantly delayed, or at a smaller scale than reported. AEMO's electrification forecast (which is not specifically allocated to the LIL forecast, but is a key forecast component in its own right) includes material electricity consumption growth as new loads electrify and connect to the grid, including in South Australia. AEMO recognises the potential impact though that industrial load growth may have on the investment needs of any jurisdiction. For the 2024 ISP, AEMO will examine potential events that may increase, or reduce, the need for transmission investments. For example, in the event that significant consumer load growth opportunities for new industrial, mining and manufacturing loads in regional South Australia become committed, that may need transmission investment to support efficient and effective operations. AEMO will explore whether such an event – that is, the potential commitment of significant new loads beyond general growth and electrification forecasts – would support alternative development preferences.

3.4.11 Demand side participation

Consultation questions that prompted feedback in Draft 2023 IASR

- Do you consider it reasonable to target the 8.5% by 2053 in the high growth case in the table above, or should that potentially be brought forward?

Considering the effect of the final 2023 IASR scenario consolidation, AEMO has decided to adapt the target for DSP as percentage of peak demand for the *Step Change* scenario to the lesser of the two *Step Change* scenario variants within the Draft 2023 IASR. In so doing, the DSP forecast provides a more appropriate spread of outcomes across the three scenarios. AEMO also has determined that the timing of reaching this proportion should not be pushed out in each forecasting iteration, as it was previously attached to the final year of the

[26] Standing information request for 2023 is at https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/nem_esoo/2023/aemo-standing-information-request-for-2023.pdf.

[27] Forecasting Approach – Electricity Demand Forecasting Methodology August 2022 is at https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/nem_esoo/2022/forecasting-approach-electricity-demand-forecasting-methodology.pdf?la=en.

forecast, whereas the intent was to achieve this level by 2050. AEMO will continue to monitor the degree of uptake of DSP, as submitted to AEMO through the DSP information portal, to ensure the forecasts remain appropriate.

In response to the consultation question above and the topic in general, stakeholders submitted this feedback:

Feedback received	AEMO response
Regarding DSP estimates: **FFI** noted that it was not clear on what was, or was not, included in the 8.5% demand side participation in the published works. The **ISP Consumer Panel** also sought clarity on the use of US and European data for forecasting long term CER. Its view was that 8.5% may be plausible with more analysis but would require continuous improvement to the Wholesale Demand Response Mechanism. **Ausgrid** asked for more commentary on the assumptions regarding DSP participation rates and how consumers use DSP technology. FFI also noted that: • The New South Wales scheme is a mechanism to encourage peak demand response, but it is questionable if it is sufficient to create an incentive larger than the upper limit identified by the international studies. • Tasmania can be exposed to high spot prices when there is no price separation from the Victorian pool price, which is more likely when Marinus Link is completed.	AEMO acknowledges that information about technology and end-user interaction is fragmented, with information on uptake of flexible consumer demand being reflected through many different parts of the forecast, such as the battery storage forecast, EV forecast, and the DSP forecast and assumptions about orchestration of such technologies. AEMO has added a summary to the DSP section of the IASR providing a holistic overview of all types of demand side flexibility, assumptions about consumer engagement with these technologies. AEMO's DSP forecast covers flexible demand not captured in other parts of AEMO's forecasting processes. As noted in FFI's submission, there are significant components of demand flexibility from EV charging, price responses, batteries, etc. Appendix A6.1 in the 2022 ESOO illustrates the extent those components fall outside AEMO's definition of DSP. That summary excludes flexibility from electrolysers. For the avoidance of doubt, these are excluded from the DSP forecast as their operation is modelled directly to account for any variability in operation in response to price or reliability signals. AEMO acknowledges the challenges in forecasting DSP out to 2050, and hence uses scenarios to explore a range of different outcomes. Looking at international studies, AEMO focused on studies that in particular excluded flexibility from batteries/EV to ensure the reported penetration of DSP was comparable to AEMO's definition. The international studies that have been used to guide the target have been selected to ensure they fit with AEMO's definition of DSP and include no (or insignificant) response from EVs and batteries (which are modelled separately by AEMO). Similarly, hot water load control will be excluded as that is already reflected in AEMO's forecast. Regarding specific jurisdictional programs: • The PDRS is an ambitious scheme. AEMO has engaged with the New South Wales Government to ensure the PDRS is accurately modelled in the DSP forecast. • AEMO appreciates FFI's insight that Marinus Link may cause prices in Tasmania to more closely follow those on the mainland. After considering this, AEMO will use the same target percentages as the mainland regions.
Regarding demand response: **FFI's** submission: • Noted that demand response is typically challenging to model. Demand profiles assumes uptake for CER storage and energy efficiency. These assumptions are all highly influential on the outcomes of AEMO's modelling, particularly the ISP. • Noted that separation of network vs non-network solutions should only be considered for addressing particular constraints and challenges in meeting peak demand in specific locations. • Stated FFI believed that in a strong hydrogen future, demand response can play a critical role. There are options to operate hydrogen production plant flexibly for the benefit of both the operator and the system. FFI noted that system reliability can be improved if new loads incentivise new generation but avoid consuming at times when prices are high or supply is low.	AEMO agrees on the importance of assumptions surrounding CER uptake and the spread of assumptions across scenarios is designed to capture a broad range of potential futures. See Section 3.3.8 in the 2023 IASR for details. Regarding the impact of demand response, AEMO also agrees, with AEMO modelling increasing levels of DSP in the future across most of our scenarios. In line with the AER's Cost Benefit Analysis Guidelines, AEMO is open to early engagement with non-network proponents to help inform options considered in the Draft 2024 ISP. As discussed in the ISP Methodology, AEMO model's electrolyser loads such that its development and operation are optimised between providing extra production capacity to increase load flexibility, with the capital cost of such developments. As such, they are assumed to operate flexibly where efficient, and minimise total costs while meeting assumed production targets.
Regarding DSP terminology:	AEMO's assumptions to a large extent build on bottom-up estimates of potentials, including consultancies providing estimates for energy

Feedback received	AEMO response
The **EEC** noted its preference for 'energy management' as a collective term covering energy efficiency, load shaping and demand response. It recommended: • AEMO to undertake bottom-up analysis to determine the potential for energy management improvement in the period 2023-2050; • AEMO should use 'energy management' as a sensitivity analysis on all scenarios.	efficiency (for both appliances and buildings) as well as uptake of battery storage and EVs, with the latter two providing key technologies for load shaping and DSP. There are significant opportunities for load shaping/DSP beyond these though and AEMO is through its DSP Information survey once per year getting updates from all registered market participants about their various programs providing demand flexibility of any kind. These are used to inform AEMO's DSP forecasts. Given forecasts are done at component level, the terminology generally focusses on those rather than umbrella terms such as demand management, but AEMO will provide some more commentary about how these components do link together. AEMO notes that DSP and energy efficiency as well as uptake load shaping technologies such as EVs and battery storage is varied across scenarios and sensitivities already.

3.5 Existing generator and storage assumptions

3.5.1 Generator and storage data

The Draft 2023 IASR described AEMO's process for capturing generator and storage data, and this feedback was received.

Feedback received	AEMO response
Regarding the data currency of AEMO's quarterly Generation Information: **QEUN** noted that AEMO's Generation Information Page is outdated. QEUN recommended all state, territory and federal energy Ministers provide applications, approvals, changes to generation, and storage projects in their respective jurisdictions to AEMO on a monthly basis.	According to NER 3.7F(d), AEMO is required to update the generation information page no less than quarterly. While AEMO is required to publish updates on a quarterly basis, AEMO also aims to publish more frequent updates when there are major updates, including out-of-cycle releases as soon as practical. Generation information is compiled based on surveys submitted by project proponents who are requested to submit information on all projects they are considering. It is also augmented with connection information for projects that have requested connections.

3.5.2 Generator operating limits

Consultation questions that prompted feedback in Draft 2023 IASR

- Do you have specific feedback and data on the assumed technical and cost parameters for existing generators?
- If you are an operator of an existing generator, do you have any specific technical or cost data that you are prepared to be used in AEMO's modelling? It would be preferable if this was data that was able to be published, but confidential data would also be considered.

Feedback received	AEMO response
Regarding synchronous generators: **CEC** recommended that AEMO consider the assumptions regarding the minimum number of synchronous generators required to be online for a stable configuration. **CEC** pointed to AEMO's assumptions being based on "internal analysis of historical generation and operational experience". **CEC** further suggested that these assumptions should be reconciled with AEMO's commitment (via the Engineering Framework) to moving the power system through a series of hold points in	AEMO agrees with CEC's comments relating to 'hold points' and implementing a gradual reduction in the minimum number of synchronous generators required to be online over the ISP modelling period. For the 2024 ISP, assumptions regarding minimum stable generator combinations have been adjusted to reflect experience from South Australia, by now having a gradual reduction of requirements of synchronous machines online, as opposed to no requirement after 2025. This can be seen on the 'Power System Constraint' tab in the 2023 IASR Assumptions Workbook. This approach, to progressively reduce the

Feedback received	AEMO response
which the number of synchronous units required to be online is reduced over time.	number of synchronous generators online, is reflected in AEMO's *Engineering Roadmap to 100% Renewables*.

3.5.3 Forced outage rates

The Draft 2023 IASR described AEMO's forced outage rate assumptions, and the following feedback was received.

Submission	AEMO response
Regarding outages, robustness to them and modelling approach: **FFI** submitted that: • The system needs the capability to manage generator outages without perfect foresight and additional targeted investment or energy stockpiling. • Forced outage rates are showing substantial increases, with increases of around 20% since the previous IASR. • The 'lumpiness' of outages must be maintained in modelling.	AEMO bases its outage rate estimates on numbers collected from participants as well as historical information. Forecasts used for large thermal generators consider the most up to date information and will often change over the forecast horizon based on future maintenance and operation schedules. AEMO reports each year on the new unplanned outage rates to the Forecast Reference Group. Changes to forecast outage rates can have a material impact to forecasts thus AEMO analyses and updates these rates each year to obtain the latest information available. The outage rates are also considered in reliability assessments of the grid, including the ESOO. These forecast unplanned outage rates are often increasing as generators age. Although long duration outages are shown as smoothed, AEMO runs thousands of iterations for each year which gives us a range of outage outcomes. The average outcome of all the iterations is expected to look 'smooth' as per the forecast presented but each individual iteration will be more lumpy due to both long duration outage and AEMO's approach of using four separate outage rates for our standard unplanned outage rate assumptions.
Regarding consideration of outages, their frequency and costs: **FFI** noted that the ISP does not usually capture the cost implications of a system under substantial stress due to extended long-duration outages or black swan events, which drive the investment of the "pure capacity" supply or demand response options such as trading cap contracts, transmission avoidance or distribution avoidance. The **CEC** submitted that AEMO should carefully assess assumptions around forced outage rates and long-duration outages: • The improving forecast outage rate in the report seems inconsistent with historical trends, where observed outage rates in fossil fuel generators have been increasing. • The loss of a large thermal unit providing system strength and other system stability services warrants AEMO's careful consideration of the impacts of large outages.	The ISP is developed such that the ODP meets the requirements of a reliable and secure system over the outlook period. The effectiveness of the ODP at maintaining reliability and security is validated through sensitivity testing, resilience analyses through time-sequential market modelling, and power system analysis. Additionally, the ODP is selected considering the outcomes of the CBA about maximising net market benefits and the minimising potential regrets associated with the ODP. The ODP needs to represent a robust and resilient power system that reasonably balances benefits and risks in accordance with consume risk preferences. On the treatment of high impact, low probability (HILP) events, AEMO follows the provisions from NER S5.1.2 and S5.1.8 regarding transmission planning when developing the ISP. While these provisions allow AEMO to consider black swan events, AEMO believes these types of analysis is better suited to be investigated in the RIT-T stage where there is better confidence in the costings to see if there is justification for the additional level of work. Forced outage rates are based on assumptions provided by market participants. While individual participants tend to report worsening reliability rates as generators age, the aggregate improves over time as more unreliable power stations retire (as these are progressively removed from the aggregate). The underlying station-level rates, which are confidential and not published, are more consistent with CEC's suggestions. AEMO tests the outage rates provided by each generator against historical rates, previously supplied values, industry averages as well as factors supplied by consultants. AEMO reviews trends and liaises with participants on any potential anomalies. AEMO reviews all ISP outcomes to ensure they meet system strength and stability requirements. Separate system strength studies also test the resilience of the network to outage events.

3.5.4 Generator retirements

Consultation questions that prompted feedback in Draft 2023 IASR

- Do you have any views on the approach described to address generator retirements?

Feedback received	AEMO response
Regarding announced closures and credibility of coal generation after 2035: **Iberdrola** noted it is critical that AEMO continue to focus on coal closure trajectories consistent with the scenarios, regardless of announced closures that will inevitably be brought forward. **Iberdrola** questioned the credibility of any scenarios that include coal generation after 2035 and recommended an accelerated coal closure scenario with no coal generation after 2030.	AEMO notes that the methodologies deployed in the ISP explore a range of coal closure timings through the use of carbon budgets that vary across the collection of scenarios. Considering the scale of rapid change required across the scenario collection, AEMO considers that accelerated coal closures are a key stress-test of the power system's investment needs, particularly for scenarios and sensitivities that apply a 1.5°C compatible carbon budget for the NEM. The inclusion of a *Rapid Decarbonisation* sensitivity will explore the impact of a faster pace of transition for the NEM relative to *Step Change*, likely to increase coal closures.
Regarding cost of generator retirement: **FFI** noted it is unclear how the cost of generator retirement is used in the modelling and noted that care is needed when using such assumptions. Once a generator is commissioned, the decommissioning cost is effectively a sunk cost. It can be delayed or managed in a variety of ways – not all of which include remaining fully operational and some can be beneficial to the growth of future industry. The key to handling the cost of generator retirement is that it shouldn't be considered as a cost-based inhibitor to ceasing operations.	Retirement cost is an input into the ISP model, and therefore is taken into consideration when the capacity outlook model optimises retirements within the carbon budgets for each scenario. While generators may have committed to the retirement cost when the project was built, the retirement cost is not assumed to be sunk in the ISP modelling. The timing of when that retirement cost is incurred is aligned with when the retirement occurs in the modelling; and it impacts the net present value of the overall system cost.

3.6 New entrant generator assumptions

3.6.1 Candidate technology

Consultation questions that prompted feedback in Draft 2023 IASR

- Is AEMO's proposed list of candidate technologies reasonable? If not, what changes should be made?

Feedback received	AEMO response
Regarding the assessment of eligible technologies: The **CEC** considered the list of eligible technologies included is lacking in several respects: • The data that feeds the IASR, and subsequently the ISP, must actively look at diverse technologies to meet sustained energy demand at all times, at the lowest possible cost. • Excluding hybrid technologies is not consistent with current practice in the NEM, where an increasing number of developers are opting for this approach (as seen in the recent VRET tender). • The list should give consideration to other forms of storage technology, such as flow battery technology and thermal storage. • AEMO should also carefully consider the likelihood of additional revenue streams that will become available to renewable generation and storage assets, such as the likelihood of system strength and network support	AEMO considers that there is a sufficiently diverse set of technology options in the modelling. AEMO recognises the important work and stakeholder engagement provided by the *GenCost 202-23* report conducted in collaboration with CSIRO, which assists to ensure regular review and consideration of diverse technologies. By considering different types of technologies, hybrid technologies are implicitly considered in the modelling since any combination of technologies could be built if they are technically feasible and help in minimising the overall system cost. That is, while AEMO does not explicitly model a hybrid generator type, it does develop REZs that may have a mixture of renewable and firming resources, which may also share connection equipment. The model may not call these a hybrid solution, the bundle of technologies may be delivered in a hybrid manner and retain consistency with AEMO's forecast generation mix. AEMO's storage technologies focus on battery and pumped hydro solutions primarily due to the cost information provided by the *GenCost 2022-23 Final report* projections. The depth of storage and the flexibility to operate that storage is what is most important to AEMO's modelling, rather than any particular storage technology. If on implementation

Feedback received	AEMO response
agreements being entered into with standalone storage and hybrid assets. **ACF** also suggested AEMO exclude CCS in electricity generation, given the technology is high cost, obsolete, and risky. **Bob King** noted that nuclear and high efficiency, low emissions (HELE) coal technologies are quite likely new entrant technologies.	another storage technology (compressed air, flow, gravity etc) can provide equivalent storage operating capabilities and depth at an efficient cost, then this may be consistent with the ISP's projections. AEMO's modelling approach for the ISP focuses on minimising overall system costs, guided by the AER's Cost-Benefit Analysis Guidelines[28]. The manner in which technologies commercialise their operations and obtain revenue for their provided services is not a primary focus on technology selection, but across AEMO's publications we identify needs for various grid services; technologies that can provide both capacity and security services may be an efficient way of minimising system security gaps through the transition. AEMO considers that gas technology with CCS should remain as part of the candidate technologies list and let the least-cost expansion modelling determine if it should be selected as part of the ODP. Regarding nuclear and coal technologies: • Currently, Section 140A of the *Environment Protection and Biodiversity Conservation Act (1999)* (C'th) prohibits the development of nuclear installations. This is a legislated policy and as such AEMO is including it across all scenarios. Nuclear technology therefore is an excluded technology option. • Given the presence of carbon budgets across all scenarios, and based on the results of past ISPs, it is not expected that coal technologies will be deployed in the NEM in the future scenarios considered in the ISP.
Regarding capital costs for wind technology: **Iberdrola** agreed with AEMO's approach of adjusting down the capital cost of wind technology to mirror the turbine efficiency improvements but noted that it is difficult to judge the accuracy of cost forecasts when the turbine efficiency and capacity factor improvements are rolled into the capital cost projections.	Following stakeholder feedback to the GenCost 2022-23 consultation, CSIRO is no longer assuming improvements in capacity factors for wind. As such AEMO will stop adjusting build costs for wind reflecting the impact of assumed technical advances.
Regarding heat capture for biomass: **FFI** noted the choice to use heat capture for biomass is an efficient use of an opportunity but without understanding the demand this may have limited usefulness. **FFI** noted that there is already substantial waste heat from industrial processes in Australia, which is not captured, specifically selecting biomass to benefit from that opportunity is not technology neutral.	The consideration of combined heat and power was on the back of previous stakeholder feedback, as discussed in the *GenCost 2022-23 Final report*. AEMO's model does not currently have the capability to model separate heat demand given the need to ensure appropriate solving times and manage model complexity. This effectively means that heat demand can't drive the need to build this technology. AEMO recognises this, but as recognised by the submission, heat generated by a number of existing processes is not currently captured either.
Regarding biomass: **VBN** noted that the information about the array of biomass resources has to be noted with concern. Vic Bioenergy Network also suggest considering anaerobic digestion. VBN also suggested to update steam to heat for Table 22. **Regarding biomass, VBN** noted that the type of fuel is assumed to be chipped residues, hence, emissions would be zero.	The latest Aurecon report[29] accompanying the publication of the final 2023 IASR acknowledges the contribution of biogas through anaerobic digestion. However, AEMO does not consider that it would materially impact the modelling outputs if were included as a separate deployable technology. AEMO updated the text on the list of candidate generation and storage technology options of the final 2023 IASR as suggested. Regarding biomass emissions, the emission intensity for new entrant biomass generator has been reduced from 1270.98 kg/MWh (2021 IASR) to 20.8 kg/MWh to align with the emission factor used in the 2022 Australian National Greenhouse Accounts published by DCCEEW.
Regarding consideration of biomass and its costs: **VBN** noted that there is lack of informed content on energy from biomass and biowastes. Biomass and biowaste energy need to be recognised given available resources (potential to contribute 15% of power) and notes that more emphasis is	As discussed in the *GenCost 2022-23 Consultation draft report*, there are no operating waste to energy plants in Australia, and only two under construction. AEMO's models are limited in the amount of candidate technologies available to ensure appropriate solving times and manage model complexity, and as such AEMO believes biomass to be the preferred option to be modelled.

[28] At https://www.aer.gov.au/system/files/AER%20-%20Cost%20benefit%20analysis%20guidelines%20-%2025%20August%202020.pdf.

[29] At https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2022/2023-inputs-assumptions-and-scenarios-consultation/supporting-materials-for-2023/aurecon-2022-cost-and-technical-parameter-review.pdf?la=en.

Feedback received	AEMO response
given on hydrogen over biomass in decarbonising the gas grid despite the former being costly. GenCost 2022-23 Consultation draft reports on biomass capital cost is significantly higher (20-40%) than world or Australian built examples.	

3.6.2 Costs associated with candidate technologies

Consultation questions that prompted feedback in Draft 2023 IASR

- Do you have specific feedback or data on the assumed current and projected costs for new generation and storage technologies?
- Do you have a view on the described approach to adjust wind build costs?
- Do you agree with these proposed technical parameters, as well as fixed and variable operating and maintenance costs of new entrant technologies? If not, please provide suggestions for improvements.

Feedback received	AEMO response
Regarding PHES costs: **Hydro Tasmania** noted that PHES costs will be substantially lower than equivalent projects on mainland Australia.	As outlined in the Draft 2023 IASR, AEMO used build cost provided by Hydro Tasmania for significantly progressed PHES projects in Tasmania. These technology costs are consulted on along with all other technologies as part of AEMO and CSIRO's collaborative *GenCost 2022-23 Final report*.
Regarding losses relative to generator location: **Bob King** noted that the transmission losses are directly related to the location of generator in the electricity network and that wind and solar tend to be located further away. As the associated transmission loss factor is calculated in advance for each year, the *GenCost 2022-23 Final report* should display the range and provide an average by dispatched generation and take these into account in the Levelised Cost of Electricity (LCOE) estimates.	The capital costs from the *GenCost 2022-23 Final report* are intentionally forecast to be exclusive of the impact of network losses so those different drivers are accounted for separately in AEMO's ISP modelling.
Regarding operation and maintenance costs: **ASTRI, Fichtner and ITP** noted that operating and maintenance (O&M) costs are largely presented as fixed costs per MW per year. Their joint submission recommended re-casting O&M costs as a percentage of capex per year to reflect different solar field sizes and will also allow the O&M costs to reduce year by year in proportion to capex reductions, which we argue is a reasonable default model.	The approach taken to fixed operation and maintenance (FOM) costs, variable operation and maintenance (VOM) costs and build costs is consistent across technologies. FOM and VOM costs are derived from Aurecon's estimates[30] for known technologies in dollars, rather than a share of build costs. There are no significant improvements in the FOM and VOM costs expected across the outlook period. Build costs, on the other hand, are derived from projected estimates from *GenCost 2022-23 Final report* and are mostly driven by learning rates and technology deployment. These two sets of costs are driven by different factors, hence the difference in treatment.
Regarding cost estimates and uncertainty: The **ISP Consumer Panel** expected that the further out the forecasts, the larger the possible build cost range and the less certainty that a point is indeed a symmetrical mid-point, particularly where a technology like hydrogen is still in its 'early learning rate' stage. The **ISP Consumer Panel** believed this suggests the need to put some risk factors around the estimates when used in the	There is a significant degree of uncertainty around the outcomes regarding future build costs. Aurecon highlights in its report a significant accuracy band (+-30%) around its cost projections. There is, however, less uncertainty for those technologies that are mature or towards maturity, such as onshore wind and solar farms, hence a single-value cost forecast is sufficient to represent a range of cost forecast. While the accuracy range for further out forecasts for transmission costs may be wider, this doesn't impact on the expected value that is used in

[30] At https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2022/2023-inputs-assumptions-and-scenarios-consultation/supporting-materials-for-2023/aurecon-2022-cost-and-technical-parameter-review.pdf?la=en.

Feedback received	AEMO response
ISP modelling, using the AACE approach in network cost estimates.	the modelling. Increases in expected costs is separately considered as part of the cost forecasting process.
Regarding local sourcing requirements: The **ISP Consumer Panel** pointed out that state governments have a range of local procurement policies designed to increase the level of local sourcing of materials in their state. Local procurement policies and union coverage requirements are expected to have a significant impact on costs.	CSIRO's *GenCost 2022-23 Final report* projection has not incorporated adjustments for an increase in local content. CSIRO agrees this might have some impact but cannot see any objective way to make this change with the available information.
Regarding Concentrating Solar-Thermal cost models: **ASTRI, Fichtner and ITP** noted that the Fichtner Concentrating Solar-thermal Power (CSP) cost model represents the most accurate, detailed, up to date assessment of CSP deployment costs within Australia and that the CSP cost data in the three datasets (i.e., AEMO, GenCost 2022-23 Final report and Aurecon) differ. The joint submission sought additional CSP configurations for the ISP modelling and refinement of CSP configuration using recommended CSP cost model.	AEMO and CSIRO have revisited the cost assumption for CSPs to be approximately 10% lower than what was assumed in the *GenCost 2022-23 Consultation draft report*. These figures are published as part of the 2023 IASR.
Regarding cost methodologies: **SOS** suggested that the LCOE method is a flawed approach, and listed multiple examples of where electricity prices are higher due to unstable VRE production. SOS also noted that emissions to produce VRE components are high.	AEMO does not rely on an LCOE value for determining the optimal mix of generation, storage and transmission investment, rather applying detailed economic models that consider the costs and benefits by cost component and market benefit class (as per the AER's CBA Guidelines). The LCOE analysis in the *GenCost 2022-23 Final report* is published primarily to enable ease of comparisons across technologies where detailed models are not available to readers to perform these fundamental calculations. Further information on CSIRO's approach to forecasting generation technology costs is within the CSIRO *GenCost 2022-23 Final report*.

3.6.3 Supply chain constraints

Several submissions were received pertaining to current inflationary pressures on development costs and supply chain constraints.

Feedback received	AEMO response
Regarding costs and their probabilities: The **ISP Consumer Panel** expressed concerns about how the 'base year' cost numbers (from Aurecon) are then represented in CSIRO GenCost 2022-23 Consultation draft forecasts. The **ISP Consumer Panel** pointed out that the CSIRO GenCost 2022-23 Consultation draft forecasts make no mention of an accuracy range and seem to be a point estimate. The **ISP Consumer Panel** questioned if these are symmetrical estimates with an equal probability of an increase of decrease? If so, the Panel suggested it should be stated and explained.	CSIRO considers that it is more useful to stakeholders to have a single point forecast that can be tracked over time as the known actual value, although acknowledging that actual values will, in reality, represent a range.
Regarding capital costs, supply chain, and inflation: **Marinus Link** noted the following regarding the *GenCost 2022-23 Consultation draft*: • Assumptions that the capital costs revert to 'normal' by 2027 could be reassessed. • Equipment contracts are locked at least 2-3 years before commissioning. • Global demand for manufacturing of renewable generation and storage raw materials required is robust. • Assuming a reduction in capital cost in real terms within the next five years may be challenging.	For the consultation, the *GenCost 2022-23 Consultation draft report* did assume all technologies have a common return to normal year of 2027 and sought responses to the proposed four-year high price cycle (the scenarios diverge thereafter). Given the stakeholder responses, CSIRO now models the current inflationary cycle to last until 2027 for the 'Current Policies' scenario, which aligns with AEMO's *Progressive Change* scenario, and 2030 for all other scenarios. CSIRO consider that scenarios with slower uptake of technologies would resolve quicker than those with higher and faster uptake.

Feedback received	AEMO response
• Capital costs, large-scale PV appears to be lower than other generation technologies such as wind and open cycle gas generators. **Shell** noted that supply chain constraints on BESS, wind, solar have not been adequately captured enough for short, medium and longer terms. The **ISP Consumer Panel** further noted that it is difficult to believe that even if the economy-wide CPI is back to 'normal' by 2027, that inflation in generation and network construction will be back to its pre-COVID rate. The Panel suggested that the *GenCost 2022-23 Final report* modelling could provide increased transparency on how the GALLM modelling takes account of supply chain constraints. **Iberdrola** agreed with AEMO's near-term increase in CAPEX costs, but was less certain of the rapid reduction in costs from 2028, which were similar to previous ISP capital cost projections.	
Regarding capital cost updates: **EnergyAustralia** noted that capital cost estimates presented by Aurecon and CSIRO already reflect recent cost increases, however in many cases these are still below what EnergyAustralia expects developers are likely to be facing in the current market.	The figures provided in Aurecon aim to represent the most updated information at the time of drafting, notwithstanding the fact that, as correctly argued by the submission, there is likely to be an unavoidable time lag. Cost estimates are based on Aurecon's internal database of projects that are recently constructed or under construction; on recent bid information from EPC competitive tendering processes; on industry publications, publicly available data; and on vendor information. Additionally, as discussed in the *GenCost 2022-23 Final report*, further increases to 2024 due to inflationary pressures and supply chain constraints have been incorporated into the projections. These are projected to be eased off over the period to 2027 or 2030, depending on the scenario.
Regarding relativities between coal price and capital costs: **FFI** noted a difference between how fast the coal price recovers and how fast new build capital costs recover.	For the consultation, the *GenCost 2022-23 Consultation draft report* did assume all technologies have a common return to normal year of 2027 and sought responses to the proposed four-year high price cycle (the scenarios diverge thereafter). Given the stakeholder responses, CSIRO now models the current inflationary cycle to last until 2027 for the 'Current Policies' scenario, which aligns with AEMO's *Progressive Change* scenario, and 2030 for all other scenarios. CSIRO consider that scenarios with slower uptake of technologies would resolve quicker than those with higher and faster uptake. In contrast, the export thermal coal price has been influenced by international commodity prices due to the war in Ukraine and Russian energy sanctions. Coal price caps of $125 per tonne are in place until 30 June 2024 for coal purchased by export exposed power stations in New South Wales and Queensland. AEMO considers the differing dynamics associated with the *GenCost 2022-23 Final report* and coal price forecasts operate over different timeframes.
Regarding employment factors: The **ISP Consumer Panel** noted that the Institute for Sustainable Futures, University of Technology Sydney (UTS) report AEMO uses to estimate employment factors for generation technologies highlights considerable risks in the availability of the required labour for both local component manufacturing and generation construction. The Panel suggested there should be transparency around the consistency of the *CSIRO GenCost 2022-23 Consultation draft* forecasts and the employment factors. The Panel also inquired if the CSIRO GenCost 2022-23 Consultation draft analysis effectively assumed that whatever labour is required will be available and at the same cost base as the Aurecon 2021 estimates.	CSIRO method used for the *GenCost 2022-23 Final report* assumes that labour costs are part of the assumed multi-year high price cycle and that their method for including this cycle implies that labour costs resolve back to their long-term trend as part of that cycle. A specific labour cost index is included as part of the bundle used for the long-term changes in mature technologies. CSIRO *GenCost 2022-23 Final report* work has assumed that this high-price cycle will resolve at different years depending on the scenario narrative where scenarios with slower uptake of technologies would resolve much quicker than those with higher and faster uptake.

Feedback received	AEMO response
Regarding availability of capital amongst global competition: The **CEC** noted another uncertainty that would impact Australia is intensifying global competition for green capital, clean energy equipment, skilled workers, precipitated by the passing of the US Inflation Reduction Act in August 2022; and that the uncertainties associated with these events relate to the nature of Australia's response. Its submission noted that if the Commonwealth Government decides to respond (as many other economies are doing) with its own clean energy package which will enable Australia to compete with the US in some areas of comparative advantage, we could see the costs or commercialization gaps for certain technologies (for example, renewable hydrogen) close earlier than otherwise anticipated. The **ISP Consumer Panel** noted that there may be supply chain and other impacts resulting from the US Inflation Reduction Act, and suggested that AEMO's multi-sector modelling be updated to seek to assess the impact of that policy in particular.	AEMO recognises that policy settings, global dynamics, and supply chains are key uncertainties. The scenarios AEMO forecasts to provide a breadth of perspectives to cover different paces of change, and sensitivity analyses are planned to explore the resilience of investment needs to the impacts of several of these uncertainties. In light of the feedback AEMO received regarding the appropriateness of the discount rates as proposed in the Draft 2023 IASR, AEMO commissioned OEA to survey market participants on their costs of capital, the drivers for those, and the impacts those drivers would likely have. The survey suggests that while the US Inflation Reduction Act makes investments in the US more attractive, investors still see Australia as good investment destination; and that the US Inflation Reduction Act is expected to have little impact on the costs of capital for projects in the Australian energy industry. AEMO considers that the US Inflation Reduction Act will have a global influence on capital availability and supply chains, however whether that is positive or negative for the investments needed for the NEM in the short, medium and long term is highly uncertain. AEMO considers it premature to expect that multi-sector re-modelling could have an improved interpretation of the policy impact, especially considering the policy's maturity. AEMO considers that the scenario set covers a sufficient breadth of supply chain eventualities and may deploy further sensitivity analysis in the ISP to expand that breadth if needed.
Regarding cost volatility: **FFI** noted that for some reason solar, and to a lesser extent gas, have been exempt from the rising price pressure. FFI further notes that it is good that the modelling considers the influence of the current costs but it is questionable how long these high prices will continue.	The impact of cost pressures as presented in Aurecon's report is not uniform across technologies, with wind and batteries being more severely impacted, calling out lithium carbonate price increases impacting BESS prices, as well as global competition for key components and technologies impacting wind turbine prices. As discussed in the *GenCost 2022-23 Final report*, the trend for projected costs from S&P Global was applied to Aurecon estimates over the period to 2024. These estimates were then interpolated to 2027.

3.6.4 Locational cost factors

Consultation questions that prompted feedback in Draft 2023 IASR

- Do you agree with continuing to use the same regional cost factors as the previous ISP? If not, please provide suggestions for improvements or alternative data sources.
- Are there any other considerations that should be factored into these regional cost factors?

Feedback received	AEMO response
Regarding simultaneous projects: The **ISP Consumer Panel** noted that NEM locational cost factors in Table 25 of the Draft 2023 IASR says "…exclude cost premiums that may arise if multiple projects are simultaneously competing for scarce resources across the construction supply chain." The Panel noted that this is exactly the situation Australia is facing in the next decade – not just multiple simultaneous generation and network projects in the electricity sector, but significant construction activity all through the economy. Various Infrastructure Australia reports highlight the massive expansion in projects and the severe constraints from having multiple projects proceeding simultaneously.	Location cost factors are intended to be used to differentiate the costs between the locations in the NEM. On the back of the 2021 IASR stakeholder feedback, AEMO adjusted the locational cost factors to take into account the impact of locations' proximities to cities and ports but normalised each state to remove inter-state impact of labour and other costs. The impact of supply chain pressures is incorporated via the build cost forecast themselves (which multiply these factors) as projected by the *GenCost 2022-23 Final report*. AEMO intends to run a sensitivity to explore the impacts of supply chain and social licence limitations and/or cost impacts, which is similar to that proposed by the Consumer Panel regarding concurrent project developments.
The **ISP Consumer Panel** noted that they had no confidence that the location cost factors will be anywhere near what is currently the case, or expected to be the case, over the next 10-20 years. The Panel argued that the period since 2018-19	Location cost factors are intended to be used to differentiate the costs between locations in the NEM. AEMO adjusted the locational cost factors to consider the proximity to cities, ports and labour, and then normalised each state to remove inter-state impact of labour and other costs.

Feedback received	AEMO response
has been a time of massive increase in proposed construction activity both in and outside the energy sector. The Panel suggested that no reasoning has been provided as to why regional cost factors in the 2018 Entura report should apply in 2023 and beyond. The Panel recommended that AEMO commission GHD to do an update of their 2018-19 report that also includes consideration of supply chain constraints.	Forecasting and escalation of future generation and transmission costs (an aspect that includes consideration of the global supply chain constraints) is covered in the CSIRO *GenCost 2022-23 Final report* and AEMO's *Transmission Expansion Options Report*. AEMO considers it is appropriate those factors are treated separately from global supply chain constraint impacts.
Regarding land costs: The **ISP Consumer Panel** queried if there is a consistent approach to the cost of land and biodiversity costs for generation and storage (CSIRO) and network (Transmission Cost Data Base). Further, the Panel noted that Table 24 on page 97 has technology cost breakdown ratios showing the percentage of total costs that land is. Given the location cost factor in Table 25 on page 98 for land is 1.0 for all locations, land costs are assumed to be the same everywhere. The Panel believes this approach seems inconsistent with the approach to land costs in the draft Mott MacDonald Transmission Cost database report which does show regional variation.	Following discussions with Mott Macdonald and CSIRO, locational land input costs on generation, storage and hydrogen infrastructure costs in the *GenCost 2022-23 Final report* are now informed by the land cost index as developed by Mott Macdonald, consistent with transmission projects. Additionally, in line with this feedback, in the 2023 IASR AEMO follows the easement and property cost projections from the Mott Macdonald report[31] (see Section 2.2) to derive the locational cost factors for the land component of all generators and storage. This ensures a similar treatment for transmission and generation. There are some differences in the treatment of boundaries for costs applied for South Australia between the 2023 IASR and the 2023 *Transmission Expansion Options Report*. This change in inputs appropriately considers the lower cost of land and easement in regional areas relative to metropolitan areas and is only applied to the land component of the projects. The change in inputs makes minimal impact to candidates' overall capital costs. In line with this feedback, AEMO has applied relative land cost factors derived from Mott Macdonald to the locational cost factors, to ensure a similar treatment for transmission and generation.

3.6.5 Storage modelling

Consultation questions that prompted feedback in Draft 2023 IASR

- Do you have a view on the cost assumptions for pumped hydro?
- Do you consider the adjustments to pumped hydro limits reasonable?
- Do you consider the proposed approach to model battery storage technologies appropriate?
- Do you consider the proposed change to solar thermal technologies appropriate?

Feedback received	AEMO response
Regarding round-trip efficiency of hydro generation: **Simon Bartlett** noted that AEMO's assumptions include an assumed round-trip efficiency for Snowy 2.0 of 74% compared with a round-trip efficiency of 70% assumed for the Wivenhoe PHES. It is understood that the 74% assumed for Snowy 2.0 is a theoretical calculation from the Snowy 2.0 feasibility study report whilst the 70% for Wivenhoe may be based on its actual performance. However, as explained in the Snowy 2.0 feasibility report, its round-trip efficiency can deteriorate quite significantly if Snowy 2.0 is operated at higher levels of generation and pumping than assumed for the 74% calculation as well as when the surface of the concrete lined tunnel becomes pitted by	Snowy Hydro has advised that it expects no material changes to previously provided assumptions for Snowy 2.0.

[31] At https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2023/2023-teor/mott-macdonald-transmission-cost-database-update-final-report.pdf?la=en.

Feedback received	AEMO response
operation at full generation or full pumping for excessive durations.	
Regarding round trip efficiency of batteries: **Hydro Tasmania** noted that AEMO accounts for battery storage degradation in large-scale batteries through a reduction in storage capacity by 16%. Hydro Tasmania sought to clarify whether AEMO also accounts for the decline in round trip efficiency of large-scale batteries and CER batteries. Hydro Tasmania considered that a further discount to storage capacity (similar to the approach to reflect battery storage degradation) is a reasonable approach to reflect declining efficiency of batteries in the modelling.	AEMO models capacity degradation of both large-scale and CER batteries. AEMO notes battery round trip efficiency varies mostly due to heating and cooling, but that in general round trip efficiency reduction over the battery lifetime is minimal relative to capacity degradation.
Regarding modelling of battery availability: **FFI** noted that a model with perfect foresight will select plant to start on time by choosing to commence start up perfectly to be prepared for operation when needed. In reality, such outcomes are not known and longer-start up units struggle with this more than the more dynamic units. **FFI** suggested capturing this since it is a material operational issue that will likely be underestimated due to the use of a linear optimisation. **EnergyAustralia** noted that it seems unlikely that storage capacity would be fully available for energy arbitrage given alternative ancillary and new essential system services markets.	AEMO's models are computationally intensive, and as such a number of simplifications are necessary. The drawbacks of perfect foresight are noted, and AEMO had proposed amendments to storage optimisation in particular for shallow devices. Given stakeholder feedback to the Draft ISP Methodology, AEMO has decided to monitor the influence this may have in detailed time-sequential validations of the development outcomes, rather than applying strict energy-limits to shallow devices. Please refer to the 2023 ISP Methodology Consultation Summary Report regarding perfect foresight and participation in other markets.
Regarding pumped hydro maintenance: **Origin Energy** noted that the Draft IASR assumes a 0.27% maintenance rate for pumped hydro storage, which appears to be low based on existing planned outages. Origin Energy recommended AEMO consider a higher rate and noted that more information on how the rate was derived would also be helpful.	This maintenance rate is derived from GHD (2018)[32], based on a typical annual runner inspection of a single day per year, in which the unit is electrically and hydraulically isolated for inspection.

3.7 Fuel and renewable resource assumption

3.7.1 Thermal fuel costs

Consultation questions that prompted feedback in Draft 2023 IASR

- Do you have any feedback on the assumed gas price and/or coal price trajectories?

The Draft 2023 IASR acknowledged that policy change such as price caps had not been reflected in the draft thermal fuel cost forecasts (for coal and gas), and it may be appropriate for these projections to be updated. Several stakeholders (including the **ISP Consumer Panel**, **RE-Alliance** and **FFI**) agreed, acknowledging also that there may be a similar effect from the Mandatory Code of Conduct (including a reasonable pricing provision) to be developed by the Australian Competition and Consumer Commission (ACCC). AEMO engaged ACIL Allen to provide updated gas price forecasts which include these considerations. These were presented to the FRG in June 2023 and included in the 2023 IASR. For coal prices, the Newcastle export thermal coal price forecasts,

[32] See https://www.aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/inputs-assumptions-methodologies/2019/9110715-rep-a-cost-and-technical-parameter-review---rev-4-final.pdf?la=en.

provided by OEA and published in the Draft 2023 IASR, has been updated so the $125 per tonne thermal coal price cap will apply to export-exposed coal power stations until 30 June 2024.

3.8 Financial parameters

3.8.1 Discount rates

Consultation questions that prompted feedback in Draft 2023 IASR

- Do you have a view on the proposed discount rates that will be applied in the 2024 ISP?
- Do you consider that the discount rate is appropriate for private sector investment, consistent with the guidance in the CBA Guidelines?

Stakeholders submitted on a broad range of aspects relating to discount rate, including factors to be considered, methods of computation, the engagement of consultants, and the degree of dynamism of the result. The most popular topic was on the suitability of the Draft IASR discount rate for private sector investors, and so AEMO surveyed additional local developers. The results are presented in the 2023 IASR.

Feedback received	AEMO response
Regarding the CBA methodology: **Simon Bartlett** noted that the net present value (NPV) of benefits appear to be the incorrect objective function, which only includes annualised costs over the modelling period ending 2050-51. **Shell** noted that AEMO should engage expert consultants with a key question regarding the use of the same discount rate for costs as well as benefits.	AEMO has previously engaged stakeholders on this topic and considers that terminating the NPV calculation at the end of the outlook period is a conservative approach to treating terminal values as it typically underestimates the net-market benefits. Towards the end of the outlook period, the annual gross benefits are usually larger than the annualised cost of the transmission projects. AEMO's approach that effectively assumes that costs and benefits are equal beyond the modelling period is conservative. As laid out on Section 5.6.2 of the ISP Methodology, net market benefits are derived by subtracting the total discounted system cost of a Development Path (DP) from the total discounted system cost of the counterfactual for a given scenario. As net market benefits are effectively a reduction in costs, AEMO considers that the same discount rate should be applied to both.
Regarding discount rates: **Simon Bartlett** noted that the proposed discount rate of 7% per annum appears to be low given that the NER requires it to reflect the return that private investors would require before investing in transmission, generation, or storage infrastructure. This should be consistent with their required return on equity, current costs of debt and an appropriate risk margin and taxes. Considering the slow-down in investment due to the shortage of funds, spiralling interest rates, combined with an outlook for global recession and an escalation of the Ukraine war, it may be appropriate to assume a higher discount rate. Whilst the ISP will test the sensitivity of variations to the discount rate, it is important that the central rate is realistic. **Shell** noted that the weighted average cost of capital (WACC) applied to market-facing resources do not align well with the WACC applied to new investment, and the internal hurdle rates that would be applied to approval of a new supply-side	AEMO recognised that more information would assist to build confidence in the appropriateness of the 2023 IASR discount rate. Considering the feedback provided and to further validate the appropriateness of the proposed discount rates, AEMO engaged OEA to survey developers in the NEM regarding their cost of capital. The survey was implemented in confidence to gather empirical evidence to support a value of discount rate. The survey results suggested that 7%, as proposed in the Draft 2023 IASR, is a reasonable assumption to use for a long-term central discount rate for the NEM. The survey results also suggested that an upper bound of 10.5% is appropriate for use in the Draft 2024 ISP. These figures and the corresponding survey final report are published as part of the 2023 IASR supporting materials. AEMO also recognises the importance for stability on the discount rate, while being cognisant of changes in underlying parameters. The Synergies' report (Sections 3.4.1 and 3.4.2)[33] also provided an argument to prioritise stability while conducting thorough reviews of parameters less frequently than each ISP. This process could be complemented with an

[33] At https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2022/2023-inputs-assumptions-and-scenarios-consultation/supporting-materials-for-2023/synergies-updating-the-2022-discount-rate.pdf?la=en.

Feedback received	AEMO response
resource project may be significantly higher than that implied by the WACC. Regarding discount rates, the **ISP Consumer Panel** recommended AEMO commission a new consultancy to provide data on the expected return on private sector investments, including how that has changed over recent years. The Panel considered insufficient evidence existed that the Draft 2023 IASR values represented private sector investors' requirements. **FFI** noted that it seems extreme that the views on discount rates could move so much in such a short period of time. The investments are generally very long-term investments and discount rates should be close to the long-term mean.	interim assessment each ISP to capture material changes in primary variables such as the risk-free rate and inflation.

3.9 Renewable energy zones (REZs)

3.9.1 REZ geographic boundaries

Consultation questions that prompted feedback in Draft 2023 IASR

- Do you have specific feedback on the proposed updates to the candidate REZs?

Feedback received	AEMO response
Regarding Tasmanian REZs: **TasNetworks** supported the inclusion of North East Tasmania Offshore REZ and the identification of Bell Bay for hydrogen export opportunities.	AEMO notes TasNetworks' support for the inclusion of North East Tasmania Offshore REZ.
Regarding Queensland REZs: **Origin Energy** commented that the REZ augmentation options presented for Queensland in the Draft IASR appeared to be different from the Queensland Government's three announced Queensland REZ options.	AEMO has consulted with Powerlink and the Queensland Government to ensure alignment of augmentation options; in particular the 2023 *Transmission Expansion Options Report* now incorporates developments arising from ongoing joint planning relating to the QEJP. AEMO will engage with the Queensland Government on alignment with the Queensland REZ roadmap as the roadmap is progressed.
Regarding REZ timing assumptions: **Origin Energy** noted that it would welcome more information on AEMO's timing assumptions for REZs, including in the context of announced jurisdictional plans for the zones.	Expected transmission lead times are detailed as part of the 2023 *Transmission Expansion Options Report*. AEMO notes that REZ timings are an output of ISP modelling, so this aspect will be further detailed in the Draft 2024 ISP. Latest updates to timings for transmission projects can also be found on the AEMO Transmission augmentation information page[34]. AEMO incorporates jurisdictional policies in the ISP where relevant and where consistent with the NER.
Regarding offshore REZs: **Star of the South** noted that since the release of the Draft IASR, the **Federal Government** has formally declared the area in the Bass Strait off Gippsland. **Star of the South** recommended that changes in the declared Gippsland area should be reflected in the indicative offshore windfarm locations on the REZ map along with in the offshore REZ resource limits for the Gippsland region.	AEMO agrees with Star of the South's recommendation. The Federal Government's declaration is reflected in the 2023 IASR.

[34] At https://www.aemo.com.au/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/forecasting-and-planning-data/transmission-augmentation-information.

3.9.2 REZ resource quality

AEMO received the following feedback on the issue of REZ resource quality.

Feedback received	AEMO response
Regarding wind capacity factors: **FFI** noted that the non-REZ wind capacity factors are extremely high. For both New South Wales and Victoria, the "non-REZ" resource is actually higher than many REZ opportunities – this is clearly very different to the explanation that these resources will be lower. **Windlab** noted that the capacity factor for the "N5, South-West NSW" REZ is given as 29%-30%. Windlab has been monitoring in this region for multiple years, and can confirm that the capacity factors of wind farms in this area are likely to be in the range 38% to 46% before curtailment losses.	AEMO has reviewed the non-REZ wind capacity factors and updated these values as part of the 2023 IASR. These zones were purposely defined to be near and along the 500 kV route such that it could be safely assumed that no transmission augmentation (that would be considered prescribed network) is needed to connect generation in these locations. These non-REZs are in areas where there is not an abundance of available land, near sensitive environmental, community, or cultural land, and thus are impacted by other factors that would be detrimental to development of renewable energy. These aspects are captured in the modelling through the application of build limits and penalty factors on development of new wind and solar generation. Recognising this submission and AEMO's own review, the capacity factors for these zones have been revised down to better reflect their resource quality using the same methodology as those used for other REZs. Additionally, these non-REZs are allocated a higher land penalty factor and higher connection cost, given the expected difficulties to develop these locations (as per the above reasons). It is expected that these non-REZs will have minimal development (except for in the counterfactual), however this will be an outcome of the modelling for the Draft 2024 ISP. AEMO and Windlab have engaged directly on the resource quality in South West NSW. At this time, The two parties agreed that further analysis may be required to ascertain the resource quality in the area; AEMO has not found sufficient evidence that indicates claims that capacity factors in the range 38% to 46% would be achievable in this REZ.
Regarding the relativity of the IASR capacity factors, and observed capacity factors: **Bob King** noted, regarding GenCost 2022-23 Consultation draft's solar and wind capacity factors underpinning LCOE calculations, that 29% is the actual NEM capacity factor for wind in 2014 and 2022, and likely to fall as the best sites have already been taken, hence AEMO's choice of 35% to 44% casts doubt on the rest of the report. **Bob King** also believed solar is averaging 19% in 2022, although actual solar capacity factor for rooftop PV systems in the NEM in 2018-19 was about 22%. As such, values up to 32% are not achievable.	The *GenCost 2022-23 Final report* addressed this feedback in Section D.2.1, reviewing the wind and solar capacity factors range to reflect a low of 29% and 19% respectively.
Regarding data requirements for renewable energy capacity: **Snowy Hydro** noted that AEMO models with data from 2011-2021 however this 10-year data assessment is not long enough to capture the full range wind and solar droughts. They recommend a total profile of 30-50 years. **Snowy Hydro** also noted that there is no assessment of any offshore wind droughts.	AEMO recognises that modelling a limited number of years may capture insufficient variation in weather patterns. However, as discussed in section A4.2.4 of Appendix 4 of the 2022 ISP, a review of the rolling weekly average wind speed across the NEM between January 1980 and June 2020 show that the most recent 10 years are a reasonable representation of the observed weather conditions over the past 40 years (at least in the absence of other available datasets to incorporate a longer history of supply and demand). AEMO continues to explore methods for increasing weather patterns and has identified this within its annual Forecasting Improvement Plan. The process to firstly develop synthetic demand forecasts using historical weather patterns has been an early implementation phase, with recent methodological improvements shared with the FRG in 2023. When available and proven robust, AEMO may adopt this approach and expand weather years within the ISP, subject to appropriate consultation requirements. The offshore wind capacity factors reflect similar wind speed datasets as with onshore projects, validated where practical with measurements provided by offshore-wind developers. These aspects have been

Feedback received	AEMO response
	consulted on as part of the IASR and AEMO will take into account feedback from proponents to refine proposed offshore resource limits. Potential offshore wind droughts would be captured in the use of historical reference years in the same way that onshore wind and solar droughts exist in these years. For the 2024 ISP, AEMO will explore adaptations to historical weather conditions to increase the frequency of weather extremes, as a means to simulate potential growth in weather extremes affecting electricity demands and/or renewable generation. This is intended to increase the understanding of the resilience of the investments to potential changes to climate within a primarily renewable energy power system.
Regarding correlation of Tasmanian wind with mainland wind: **Snowy Hydro** argued that the 2022 ISP's claim that Tasmania wind output provides resource diversity with mainland sources, including Victoria, is incorrect.	While it is true that there is some correlation between Tasmanian and Victorian onshore wind due to locational proximity, analysis from the wind traces that underpinned the 2022 ISP highlights that it is still reasonable to claim that Tasmanian wind does not correlate as highly with the rest of mainland wind, and that there is almost zero correlation with South Australia and Queensland wind.

3.9.3 REZ resource limits

Consultation questions that prompted feedback in Draft 2023 IASR

- Do you have specific feedback on the proposed REZ resource limits?
- Is the capacity density for offshore wind farms of 5 MW/km2 appropriate for the calculation of offshore REZ offshore wind build limits?
- Is the maximum depth of 60 meters for fixed offshore wind turbine structures reasonable?
- Is it reasonable to assume 90% of the area of the offshore REZ can be developed?
- Is the maximum land use assumption of 5% for the REZ hard limits appropriate?

Feedback received	AEMO response
Regarding REZ build limits: **Origin Energy** commented that it is not clear whether the Draft IASR build limits include existing and committed or anticipated generation capacity, or if they are based on existing or planned network capacity.	Network limits apply to all generation (existing, committed, anticipated and projected), whereas resource limits only apply to new generation (committed, anticipated and projected). AEMO has provided greater clarity on this in the 2023 IASR.
Regarding offshore wind resource limits: **Star of the South** put forward a view that AEMO's assumptions regarding offshore REZ resource limits are too generous. In **Star of the South**'s opinion, it is unreasonable to assume 90% of a declared area can be used to host operational offshore wind farms. Star of the South suggested that a figure in the range of 60-80% would provide a more realistic reflection of the area that can be used.	AEMO has accepted the feedback provided by Star of the South and will apply an 80% limit for each offshore declared area that can be used for the ISP modelling.
Regarding offshore wind turbine depth: **Star of the South** recommended that AEMO increase the current maximum offshore fixed turbine depth from 60 m to 70 m.	AEMO has accepted the feedback provided by Star of the South and has adjusted the resource limits for offshore REZs by increasing the maximum offshore fixed turbine depth from 60 m to 70 m. Separately, AEMO has also updated the offshore REZ boundaries in some cases to respond to jurisdictional bodies' advice.

3.9.4 REZ transmission limits

Consultation questions that prompted feedback in Draft 2023 IASR

- Do stakeholders have any other suggestions for representation of REZ transmission limit constraints and the secondary REZ transmission limits?
- Do stakeholders have any other suggestions for representation of inter-related constraints across multiple REZs and/or REZs and flow paths?
- Do you have any feedback on the proposed values of the REZ transmission modifiers as a result of interconnectors or sub-regional augmentations, and the REZs they apply to?

Feedback received	AEMO response
Regarding REZ transmission limits: **AusNet** made several suggestions for AEMO's consideration which are outlined below. • Improve the transparency and accuracy of REZ transmission limits by clearly defining which lines are included in each limit and make some minor Victoria-specific amendments. • Apply a range of transmission limits. AusNet suggested two values: – hot weather performance on rated lines, and – normal performance. • Apply consistent terminology (for example: capacity limits, network limits, spare or surplus hosting capacity) . • Add transmission limits for certain lines: Table 32 of the Draft IASR only provides REZ secondary transmission limits for some lines but excludes others. For example, AusNet suggested AEMO add transmission limits for the South West (SW) VIC 220 kV network and 500 kV network. • Identify 'global REZ transmission limits' in Victoria: In addition to secondary limits that is, limits within the REZ), AusNet suggests the IASR consider the degree to which generation in different REZs contributes to a constraint limit to determine dispatch capacities in wider areas. • Regarding Guthega 'interconnector': the Draft IASR appears to treat the Guthega line as an interconnector. AusNet suggested this is not consistent with previous modelling exercises and is a function of how the case is modelled in power system modelling software. • Regarding the impact of Project Energy Connect (PEC): AEMO recently consulted on the market integration activities required ahead of PEC's commissioning and energisation. There would be value in the IASR specifying how PEC will interact with existing interconnectors from a REZ transmission limit and power flow perspective.	Regarding AusNet's suggestion to apply a range of transmission limits, AEMO notes that it already provides transmission limits for flow paths for 'Summer Peak', 'Typical Summer', and Winter reference'. For the Draft IASR, AEMO determined limits for REZs based on seasonality and provided resultant limits where material. For Victoria, dynamic line ratings were applied where available. In some instances, REZs are limited by transient stability limits, which are independent of seasonality. For transparency, AEMO has noted which REZs are affected by these in the 2023 IASR. AEMO agrees that consistent terminology should be used and has applied consistent terminology in the 2023 IASR. AEMO acknowledges AusNet's comment regarding defining which lines are included in each limit. Transmission lines were not excluded in the analysis for Victoria REZs. V4 (SWREZ) is limited by a voltage stability limit and is unchanged from the previous ISP. Therefore, the V4 limit (and all other VIC REZs limits) are described in the 2023 IASR Assumptions Workbook. Regarding the suggestion on group limits, group limits have been considered for Victoria, but local limits were found to provide sufficient limiting factors, so AEMO is focusing on improving these with inclusion of interconnector flows and synchronous machine impacts. AEMO agrees with AusNet regarding its comments on the Guthega line. The Guthega line forms part of the flow path between Victoria and New South Wales, which is normally open. The 2023 IASR was amended to be consistent with previous ISPs. AEMO agrees with AusNet's comments regarding PEC, and notes that the impact of PEC on REZ limits is already detailed. Please refer to the 'REZ transmission modifiers due to committed and anticipated network augmentations' table on the 'Build Limits' tab of 2023 IASR Assumptions Workbook.
Regarding build limit determination and transparency: **Windlab** commented that build limits for many REZs are zero for wind, but non-zero for solar, or vice versa. **Windlab** further commented that some reflect transmission limits rather than renewable resource limits. **Windlab** also requested more transparency is provided regarding how build limits are determined. **Windlab** also recommended that build limits should not be determined by an assumptions workbook, but should instead be the output from an optimisation software.	Resource limits have been initially setup to reflect areas with good resources, and to reflect developer interest. AEMO has published build limits through the IASR and ISP processes over several years, and welcomes specific data in cases where stakeholders consider that changes should be made.

3.9.5 REZ augmentation and network costs

AEMO received feedback from two stakeholders about REZ augmentation and network costs.

Feedback received	AEMO response
Regarding transparency of REZ cost zones: **Origin Energy** stated that it would welcome more clarity as to how the costs for REZ cost zones (low, medium and high) are derived. In **Origin Energy**'s view, this would support stakeholders' understanding of the costs associated with each REZ.	REZ cost zones are applied to generation costs and are based on the locational cost factors which are intended to be used to differentiate the costs between the locations in the NEM. These are further described in the final 2023 IASR (see Table 23).
Regarding the planning of offshore wind zones in Victoria: **CEC** commented that, given the scale of offshore wind projects and the required supporting transmission network augmentations, clear guidance provided to the Victorian Government (by AEMO) regarding planning the declared zones would be welcomed.	Offshore wind has been mapped in the 2023 IASR to existing network and limits in order to be able to identify required upgrades to the shared network. AEMO Victoria Planning will provide appropriate advice to the Victorian Government surrounding these developments.

3.10 Network modelling

3.10.1 Network modelling, including sub-regions and existing transmission capability

Consultation questions that prompted feedback in Draft 2023 IASR

- Does the proposed sub-regional model reasonably represent the network? Are there any additional sub-regions which should be considered (and why)?
- Do you have any specific feedback on the existing and proposed flow path transfer capabilities?
- Do you have any feedback on the uplift factors applied to flow paths as a result of committed and anticipated projects?

Feedback received	AEMO response
Regarding network topology: **AusNet** suggested that AEMO provide a broader explanation of the basis for defining the sub-regional nodal topology and selecting each node for those sub-regions within the 2023 IASR.	AEMO has provided a basis for the selection of sub-regions and regional reference nodes in iterative publications of the IASR and the ISP. AEMO agrees that further explanation in the Draft 2024 ISP would be beneficial to explain the implications of the sub-regional topology for the ISP modelling outcomes.
Regarding the impact of network projects: **EnergyAustralia** requested that AEMO provide more clarity on the individual effects that minor network projects and the Waratah BESS SIPS will have on notional transfer capability between SNSW, CNSW and SNW. **EnergyAustralia** also said it was not clear what effect the SIPS scheme has on the aggregate transfer capacity between CNSW and SNW, and noted the earmarked Bannaby to Sydney West line upgrade project. **EnergyAustralia** further noted that this anticipated increase is significantly higher following entry of the Central-West Orana REZ Transmission Link.	AEMO acknowledges EnergyAustralia's request and has provided more information in the 2023 *Transmission Expansion Options Report* (Section 3.7 Central New South Wales to Sydney, Newcastle and Wollongong) and the final 2023 IASR inputs and assumptions workbook.
Regarding planning of grid augmentations: **John Diesendorf** said it is imperative that downstream grid augmentations are planned well in advance and preliminary works actioned early	AEMO agrees with the need to include downstream augmentations in network plans and do take these into account. AEMO undertakes extensive joint planning with TNSPs and jurisdictional bodies throughout the preparation of the inputs and assumptions for the ISP, as well as during the ISP modelling process.

Feedback received	AEMO response
Regarding splitting of CNQ into CQ and NQ sub-regions: **Powerlink** supported splitting the CNQ sub-region into CQ and NQ sub-regions for capturing losses.	AEMO acknowledges Powerlink's support.

3.10.2 Anticipated transmission projects

Consultation questions that prompted feedback in Draft 2023 IASR

The Draft 2023 IASR described AEMO's process for determining which transmission projects were considered anticipated projects.

Feedback received	AEMO response
Regarding the deliverability of transmission delivery schedules: **APA** noted that most of the 10,000 km of new transmission identified by the 2022 ISP was targeted to be delivered before 2030. **APA** commented that any delays to this timeframe will impact the speed at which new renewable generation can be connected to the NEM. The **WWF** expressed similar concerns.	AEMO does not agree that most of the 10,000 km of transmission is targeted to be delivered prior to 2030, as 5,000 km of transmission was not projected until 2032-33 in the *Step Change* scenario). AEMO does agree that delays to transmission delivery may impact on the rate at which new generation is able to connect to the grid. The impact of transmission delays may be tested through sensitivity studies in the ISP.
Regarding transmission build risk asymmetry: **CEC** encouraged AEMO to consider nature of risk asymmetry and put forward that the risks of going too late in regard to transmission build far exceed the risks associated with going too early. **CEC** commented that bringing forward transmission build provides an inherent buffer in the power system that helps manage the price and reliability risks associated with unplanned events. The **ISP Consumer Panel** noted that a key issue for the 2022 ISP Consumer Panel was the risk of over or under investment in transmission network and generation expansion, in the face of uncertainty around the timing of coal plant closure. The **ISP Consumer Panel** also recommended that AEMO undertake engagement to better understand consumer risk preferences. **Shell Energy** likewise recommended that in considering consumer risk preferences, AEMO should quantify risks first and consider state schemes, the New South Wales Energy Roadmap for example, in its process of quantifying risks.	The purpose of the ISP is to provide biennial assessment to ensure whole-of-system planning outcomes are delivered as efficiently as possible. AEMO agrees and is considering risk tolerance in its consumer risk preferences work, together with the ISP Consumer Panel, to better quantify the acceptable risk levels. In addition, the ISP is designed to co-optimise transmission and generation investment in the long-term interests of consumers. AEMO will publish the outcomes of this ongoing consumer risk preferences project as part of the Draft 2024 ISP.

3.10.3 Flow path augmentation options

Consultation questions that prompted feedback in Draft 2023 IASR

- The theoretical design of a counter-factual where no transmission is built is an influential part of the ISP cost-benefit analysis framework. Do you have any suggestions to enhance the approach to modelling a future without any transmission projects?

Feedback received	AEMO response
Regarding the long-term efficiency of overbuilding transmission capacity:	AEMO acknowledges FFI's comments and notes that this could be tested in the CBA analysis in the RIT-T undertaken by project proponents, to see whether larger developments can provide greater benefits. AEMO will

Feedback received	AEMO response
FFI commented that AEMO should consider the benefits of investing in larger capacity to be resilient to additional developments in later years. FFI suggested that augmentations may be better managed by larger more scale-efficient investment that future-proofs against other renewable energy development needs. FFI stated that "this is particularly important in light of the likely challenges in 'non-REZ' development".	consider this perspective when comparing the performance of development plans across scenarios.
Regarding transparency of constraints: **Shell** recommended that AEMO should set out full details of constraints included in modelling, how they are derived, and changes to current constraints and binding hours (including those close to binding).	AEMO provides significant details on constraints used within the modelling. As examples: • The Draft 2023 IASR (Table 37) presents the transfer limits and reason for changes from 2022 ISP. • The ISP Methodology paper describes how transfer limits are determined. • The *Transmission Options Expansions Report* and 2023 IASR Assumptions Workbook describe which constraint is limiting the transfer limit. AEMO welcomes specific feedback on clarifications for specific projects, or better ways to present information.
Regarding network project options: **Shell** questioned splitting projects or considering them as one in the CBA and cited HumeLink and Southern Sydney Ring as examples. **Shell** made several recommendations: • LV upgrades to defer HV lines. • Rebuild Wagga-Yass 132 kV to 330 kV. • Upgrade 132 kV network in Parkes, Orange, Forbes. • Construction of additional 220 kV lines Bendigo – Shepparton. • Install powerflow controllers on VNI lines.	Additional network upgrade options are dealt with in more detail as part of the *Transmission Expansion Options Report*. AEMO provides a response to this feedback from Shell in the 2023 *Transmission Expansion Options – Consultation Summary Report.*

3.10.4 Transmission augmentation costs

Section 3.10.6 of the Draft 2023 IASR described AEMO's approach to transmission augmentation costs. Further detail of specific network augmentations and costs has been provided as part of the Draft 2023 *Transmission Expansion Options Report*. Response to feedback on that consultation will be separately published as part of the final 2023 *Transmission Expansion Options Report*[35].

Feedback received	AEMO response
Regarding report publication transparency: The **ISP Consumer Panel** recommended that the revised Mott Macdonald report be published for stakeholder comment as part of the release of the Draft *2023 Transmission Expansion Options Report* in April.	AEMO agreed with the ISP Consumer Panel's recommendation, and the Mott MacDonald report was published as a supplementary material for consultation on the Draft 2023 *Transmission Expansion Options Report* in May 2023. AEMO has now completed the consultation, with the final Mott MacDonald report and AEMO's responses to feedback received being available via the *Transmission Expansion Options Report* consultation webpage.
Regarding additional capacity alignment: **Powerlink** said that there is considerable economic benefit in aligning, where viable, additional capacity expansion when reinvesting in transmission assets. Powerlink said it is happy to work with AEMO on this.	AEMO agrees that there are benefits in aligning additional capacity, where possible to derive scale efficient benefits. AEMO will continue to work with the TNSPs, who are expected to demonstrate this through the RIT-T and model the incremental costs and benefits.
Regarding transmission project costs and planning:	It should be noted that the location of transmission network augmentation projects in the ISP is conceptual. More detailed proposed transmission

[35] At https://aemo.com.au/consultations/current-and-closed-consultations/2023-transmission-expansion-options-report-consultation.

Feedback received	AEMO response
VFF expressed a need for AEMO's processes to understand the context of transmission options proposals in relationship to ownership, commercial consent and understanding of costs. **VFF** recommended that a full cost benefit analysis occur for projects on private land without commercial consent. **VFF** said it would welcome the opportunity to discuss the problems and the solutions with AEMO at a future date.	routes are only determined after consultation with landowners by the local TNSP. AEMO notes that, to a high level, assumptions regarding the cost of land are captured in the costings from the Transmission Cost Database.
Regarding project delays: In the **ISP Consumer Panel's** view, analysis needs to include sensitivity testing on the project (transmission and generation) schedule. The Panel said it is not confident that cost estimates in the GenCost 2022-23 Consultation draft database sufficiently reflect supply chain constraints. The Panel commented that it looks forward to seeing how the Transmission Cost Database reflects these pressures.	The updated Transmission Cost Database reflects supply chain pressures as advised by independent technical experts, with updated inputs from TNSP cost estimates. The 2023 *Transmission Expansion Options Report* considers transmission project lead times. The 2023 *Transmission Expansion Options – Consultation Summary Report* and other supplementary materials provide information about how the Transmission Cost Database and transmission cost forecasting approach have considered these supply chain pressures. AEMO may apply a number of sensitivities surrounding the timing of developments. For example, the *Constrained Supply Chains* sensitivity, as described in the 2023 IASR.
Regarding cost estimates: **RE-Alliance** noted that GHD completed the concept design and cost estimate for the undergrounding of the HumeLink Project for Transgrid as well as the Transmission Cost Database for AEMO. **RE-Alliance** also noted that two versions of the HumeLink undergrounding report were released with very significantly different costings in each case, and would be interested to see Mott MacDonald's update to the Transmission Cost Database with regard to undergrounding costs.	AEMO is unable to comment on any costing data not owned or prepared by AEMO. AEMO has released a copy of the Transmission Cost Database update and associated report as an attachment to the final 2023 *Transmission Expansion Options Report*, including additional information about comparison of overhead and underground transmission options.
Regarding transmission operations and maintenance costs: **Simon Bartlett** put forward that O&M costs for transmission developments are not aligned to an AER report. **Simon Bartlett** said they are also not aligned to the Western Renewables Link Project Assessment Conclusions Report which indicated 3.5% p.a O&M costs vs 1% p.a. This would allude to lower net benefit using 3.3%-examples of TNSP operating and capital expenditure.	AEMO acknowledges that the estimation of operating expenditure for assets with long lifecycles (exceeding 40 years) and assorted designs can be challenging, and many proponents adopt a 'per cent of new capex' rule of thumb in estimating operating and maintenance costs for RIT-Ts. In making its decision for the final 2023 *Transmission Expansion Options Report*, AEMO considered the following as evidence: • Recent completed RIT-Ts and the estimates included in project assessment conclusion reports (VNI West – 1% p.a, HumeLink – 0.5% p.a, Project EnergyConnect – 0.1% p.a). • Approved capital expenditure included in contingent project applications determinations for Project EnergyConnect ($457.4 million and $1,817.9 million $2017-18) and Eyre Peninsula ($280 million $2017-18). • Recent regulatory determinations (2023-2028) for new transmission lines: Project EnergyConnect and Eyre Peninsula, with operating expenditure values ranging from 0.6% (Transgrid) to 0.9% (ElectraNet) p.a. These values are calculated by multiplying the Base Year operating expenditure (Transgrid - $194.06 million, ElectraNet - $108.66 million $2022-23) and Forecast Rate of Change (Transgrid - 5.42%, ElectraNet 6.28%) due to new transmission lines, then dividing by the total capital cost from the relevant contingent project applications as stated above. • Announced jurisdictional strategic benefit payments to landholders and neighbours. AEMO's decision to maintain the 1% p.a value is based on recent AER regulatory determinations. These values reflect the operating expenditures that regulated transmission networks are allowed to recover from consumers, in the initial years of operation following commissioning of these new transmission lines. Both ElectraNet and Transgrid's determinations yield approximately 1% of the total capital cost per annum but vary slightly by TNSP due to a

Feedback received	AEMO response
	range of jurisdictional factors (Customer Numbers, Circuit Length, Maximum Demand, Energy). AEMO maintains that a 1% p.a. value is an appropriate estimate and has clarified its evidence for this view, to the extent possible. AEMO will apply additional operating expenditure costs for projects where sufficient justification and evidence exists for each jurisdiction.
Regarding transmission connection costs: **Simon Bartlett** noted that estimated generation capital cost estimates include allowance for the capital cost of the transmission connection for each MW of modelled generation or utility scale battery storage of around $110/kW for most locations in the NEM, but with higher connection costs in Victoria. The submission recommended that the 2024 ISP include the total transmission connection investment for all committed, anticipated and modelled generation and storage investments for each scenario so that there is a complete picture of the NEM's needs for new transmission infrastructure driving the need for skilled workers and materials.	AEMO considers the connection cost of $110/kW to be valid, as this figure represents an aggregation of costs across the system, and accounts for economies of scale by utilising higher voltage connection assets. The ISP modelling process already includes the costs of transmission investment and generator connection costs for each scenario. This information was published as a part of the 2022 ISP, and AEMO also collaborated with RACE for 2030 on the application of this data to derive electricity sector workforce projections – which is published alongside the 2022 ISP on AEMO's website[36].

3.10.5 Other network modelling matters

AEMO received feedback from several stakeholders about other network modelling matters.

Feedback received	AEMO response
Regarding transmission costs and subsidies: **EnergyAustralia stated** AEMO should confirm the coherence of its system strength remediation needs and cost assumptions, some of which arise across different publications. For example, the Draft 2023 IASR lists a value of $106/kW as included in each REZ augmentation or as a cost per connection. It would be worth clarifying how these costs relate to cost recovery by TNSPs in the presence of government subsidies for transmission development, and how therefore how this flows through to system cost benefit assessments.	AEMO acknowledges that there are a number of system strength cost values in the public domain, for the different aspects of the system strength framework and its application. For the purposes of the 2023 IASR, AEMO has published an estimate for the system strength costs associated with new generator connections. As outlined in the 2023 ISP Methodology, AEMO's approach for estimating costs includes technologies that are commercial or have been demonstrated at a large scale. For this reason, synchronous condensers will typically be used as a proxy for estimating system strength costs. In this approach, AEMO estimates the number of synchronous condensers that would provide sufficient system strength to ensure stable voltage waveforms for the connection of new renewable generators (broadly thought of as the 'efficient system strength requirement' under the updated system strength framework). This value assumes the use of 32 synchronous condensers to connect 33 GW of new renewable generation in the NEM (consistent with estimates prepared for the 2020 ISP), and the final figure of $137/kW has been updated using the updated AEMO Transmission Cost Database published as a supplementary material to the 2023 *Transmission Expansion Options Report*. AEMO has confirmed that this figure is broadly consistent with the March 2023 System Strength Service Providers' unit prices. AEMO is aware that some jurisdictions may be arranging for system strength provision in REZs through an alternate regulatory pathway rather than the system strength framework under the NER, for example through the New South Wales Electricity Infrastructure Roadmap and the Victorian Renewable Energy Zones Development Plan. Further details on these arrangements can be viewed at the relevant governments' websites.
Regarding system security: **Iberdrola** said that identifying the potential future needs to new system strength service providers, investors, and governments is of critical importance. Iberdrola highlighted that transparency and a level playing field for service providers	AEMO agrees with Iberdrola about the critical role played by system security services. The Draft 2023 *Transmission Expansion Options Report* consulted on system strength service treatment in the ISP assessment, and the 2023 IASR and final 2023 *Transmission Expansion Options Report* incorporate the outcomes of that consultation process.

[36] At https://aemo.com.au/energy-systems/major-publications/integrated-system-plan-isp/2022-integrated-system-plan-isp.

Feedback received	AEMO response
will underpin the ability to accelerate the integration of new projects across the NEM.	Note that system security assessments are completed by AEMO through NER 5.20 and published separately. Please refer to AEMO's website for AEMO System Security Planning[37].
Regarding splitting of CNQ into CQ and NQ sub-regions: **Powerlink** supported splitting the CNQ sub-region into CQ and NQ sub-regions for capturing losses.	AEMO acknowledges Powerlink's support.
Regarding information availability: **QEUN** recommended that AEMO's new Transmission Augmentation Information page needs to include a number of additional items, including: • Connection transmission to proposed, anticipated and committed generation, storage projects. • Indicative cost (as published in the public domain). • Sources of committed funding. • Length of transmission, connection transmission lines.	AEMO does not propose to include generation or storage projects in the Transmission Augmentation Information page, as these are already covered in AEMO's Generation Information (GenInfo) page. At this stage, AEMO does not propose to include connection assets in the Transmission Augmentation Information page. AEMO agrees that this information is of interest and useful for stakeholders however unfortunately it is not currently available in a consolidated format and is not AEMO-owned information. At this stage, AEMO does not propose to include indicative cost for transmission projects in the Transmission Augmentation Information page, or sources of committed funding, because AEMO is seeking to limit the information page to the most pertinent data for AEMO's modelling purposes - for example, committed versus anticipated status, or scope. AEMO will continue to incorporate the most up to date costs in relevant publications such as the ISP. AEMO notes that some of this information is available in the 2023 IASR Assumptions Workbook and in the 2023 *Transmission Expansion Options Report,* including km length of new easements for transmission lines for transmission augmentation options, and indicative project cost.
Regarding Snowy 2.0's interaction with transmission limits: **Simon Bartlett** commented that the decision by Snowy Hydro for all six Snowy 2.0 units to have variable speed motor/generators may not be reflected in the transmission limits assumed for transmission cut-sets in south-eastern Australia-since its variable speed drives-power electronic device-seen as an inverter based technology therefore reduction in the sync torque which reduces the effective inertia. It was also noted that this would produce harmonics that may degrade insulation of transformers. **Simon Bartlett** suggested the transmission limit should be reduced and investigated for PEC, HumeLink, VNI West and Sydney Ring.	AEMO has not received advice that all six Snowy 2.0 motor-generator units will have variable speed drives. Rather, AEMO's current transmission limit assumptions for the ISP and for system security planning assume that three of the Snowy 2.0 units will by synchronously coupled to the system, and that three will have variable speed drives. This is consistent with Snowy 2.0's currently published materials. Should any formal advice be received that changes these assumptions as the Snowy 2.0 project is developed, AEMO will adjust its transmission limits accordingly through engagement with the project proponent and through extensive joint planning with the local TNSP. AEMO will continue to explore any adjustments required to transmission limits as the transformation of the NEM continues, including through joint planning with TNSPs. AEMO will continue to engage with generator proponents and TNSPs on any potential for harmonics on the power system through the appropriate channels such as the generator connection process. These matters are routinely addressed through NER procedures and processes. For the purposes of the ISP modelling, inertia projections will be assessed across the ISP horizon and compared against the secure operating level of inertia and the minimum threshold level of inertia for each jurisdiction, consistent with the approach taken for previous ISPs. These secure and minimum levels are derived consistent with the NER 5.20 system security planning requirements. Should any potential shortfalls be identified across the ISP horizon, these will be considered as part of the system security appendix published with the draft and final ISP.

[37] At https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/system-security-planning.

3.11 Hydrogen Infrastructure

3.11.1 Hydrogen infrastructure needs

Consultation questions that prompted feedback in Draft 2023 IASR

- Do you have any specific feedback on the proposed hydrogen export ports?

Feedback received	AEMO response
Regarding hydrogen production and transport costs: **APGA** noted that: • The least cost H2 production is from behind the meter VRE. • The least cost transport and storage is via pipelines. • The absence of hydrogen pipelines for energy transport and storage in the modelling undermines the ability to consider the true cost of renewable gases. Similarly, **ENA** noted that in another study, both electricity transmission lines and gas pipelines were shown to have a role to play in an optimised system to deliver hydrogen to customers	AEMO recognises that the limited representation of export hydrogen infrastructure (focused on electrolyser developments at port locations, and supplied with energy delivered to that location rather than at REZ locations with hydrogen delivery mechanisms to ports) is a necessary simplification for modelling purposes, and will review model options as the scope for future ISP iterations are reviewed to extend to broader energy systems (such as will be conducted under the Federal Government's 'supercharged ISP' proposal).
Regarding water cost and availability: **QEUN** noted concerns regarding water cost and availability for hydrogen.	AEMO considers the water requirements for hydrogen production would be accommodated through the electrolyser site assessment and selection process. In areas where insufficient fresh water is available, it is assumed that desalination would be viable, with energy used for water production requiring less than 2% of the electrolyser load[38]. Water costs are a small portion of the overall cost of electrolysis, and are therefore not included at this level of analysis. However, AEMO recognises that further definition of available water sources may be needed in future ISPs.
Regarding electrolyser capital cost estimates: **FFI** noted that the assumed capital cost of electrolysers is high.	The initial estimate for electrolyser costs is based on a hypothetical Proton Exchange Membrane as discussed in the Aurecon report[39] which is deemed to be the technology that will most likely be deployed globally. This initial cost estimate is then projected forward against other technologies and reported on the *GenCost 2022-23 Final report*[40]. Capital costs are covered in the *GenCost 2022-23 Final report*, which is run under a separate consultation.
Regarding hydrogen blending: **CEC** queried the internal consistency of very high levels of green hydrogen for the decarbonisation of gas networks in the *Green Energy Exports* scenario, considering the timing of hydrogen availability in a rapid action scenario, and that consumers would need to pay for gas while waiting for green hydrogen to be available.	Based on stakeholder feedback, AEMO's updated *Green Energy Exports* scenario now limits blending of hydrogen in the gas distribution network to 10%, and includes a higher contribution of biomethane. These changes avoid the need for pipeline and consumer appliance changes. Domestic molecular fuel (across all uses) experiences no or little growth over the forecast horizon, while there is a doubling of electricity use.

[38] Calculated using data from Arup Australia technical paper *Water for Hydrogen*, November 2022, at https://h2council.com.au/wp-content/uploads/2023/02/221114-Arup-Technical-paper-Water-for-Hydrogen-report-FINAL.pdf.

[39] At https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2022/2023-inputs-assumptions-and-scenarios-consultation/supporting-materials-for-2023/aurecon-2022-cost-and-technical-parameter-review.pdf?la=en.

[40] At https://doi.org/10.25919/zmvj-tj87.

3.12 Employment factors

The Draft 2023 IASR included employment factors applied to the capacity of generation and storage build to estimate workforce requirements.

Feedback received	AEMO response
Regarding uncertainty of labour availability: **The ISP Consumer Panel** noted the difficulty in predicting states competing against each other for labour is full of caveats around the calculations and the results, and each state will have motivations to ensure their state energy objectives are deliverable from a labour perspective.	AEMO acknowledges that labour and supply chain constraints may have a material impact on the energy transition. AEMO intends to implement a sensitivity to understand the impact of constrained workforce on the delivery of projects in the ISP.
Regarding workforce modelling: **CEC** recommended that workforce modelling should be expanded to address the hydrogen supply chain, including production, storage, transport and carrier conversion. **CEC** further recommended that workforce modelling be expanded to include operations and maintenance jobs for electricity transmission and distribution.	AEMO is not aware of a reputable data set for employment factors for the hydrogen supply chain. Without this data, AEMO is unable to model the workforce requirements for hydrogen development. AEMO agrees that workforce modelling should be expanded to include operations and maintenance jobs for transmission and distribution. AEMO is not aware of a source for this information.

Appendix A. Abbreviations

Abbreviation	Meaning
ACCC	Australian Competition & Consumer Commission
ACF	Australian Conservation Foundation
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
APA	APA Group
APGA	Australian Pipelines and Gas Association
ARDL	Australian Resources Development Group Pty Ltd
ASTRI	Australian Solar Thermal Research Institute
ATR	autothermal reforming
AusNet	AusNet Services
BSL	Brotherhood of St Laurence
BZE	Beyond Zero Emissions
CANA	Climate Action Network Australia
CAPEX	capital expenditure
CCS	carbon capture and storage
CDP	candidate development pathway
CEC	Clean Energy Council
CEIG	Clean Energy Investor Group
CER	consumer energy resources
CPA	Community Power Agency
CWC	Climate Works Centre
DAC	direct air capture
DCCEEW	Department of Climate Change, Energy, the Environment and Water
DNSP	distribution network service provider
DSP	demand-side participation
ECA	Energy Consumers Australia
EEC	Energy Efficiency Council
EGA	Energy Grid Alliance
ENA	Energy Networks Australia
ESOO	*Electricity Statement of Opportunities*
EV	electric vehicle
EVC	Electric Vehicle Council
FCAS	frequency control ancillary services
FFI	Fortescue Future Industries
Fichtner	Fichtner Engineering
FRG	Forecasting Reference Group

Appendix A. Abbreviations

Abbreviation	Meaning
Greenpeace	Greenpeace Australia Pacific
GSOO	*Gas Statement of Opportunities*
HV	high voltage
IASR	*Inputs, Assumptions and Scenarios Report*
ISP	*Integrated System Plan*
ITP	*ITP Thermal*
kV	kilovolt/s
kW	kilowatt/s
kWh	kilowatt hour/s
LCOE	levelised cost of electricity
LIL	large industrial load
LV	low voltage
MCE	Ministerial Council of Energy
MW	megawatt/s
MWh	megawatt hour/s
NEM	National Electricity Market
NEO	National Electricity Objective
NER	National Electricity Rules
O&M	operating and maintenance
ODP	optimal development path
OEA	Oxford Economics Australia
OPEX	operating expenditure
Origin	Origin Energy
PEC	Project EnergyConnect
PHES	pumped hydroelectric energy storage
PIAC	Public Interest Advocacy Centre
Powerlink	Powerlink Queensland
PV	photovoltaic
QCC	Queensland Conservation Council
QEJP	Queensland Energy and Jobs Plan
QEUN	Queensland Energy Users Network
REZ	renewable energy zone
RIT-T	regulatory investment test for transmission
SEC	Smart Energy Council
Shell	Shell Energy
SIPS	System Integrity Protection Scheme
SMR	steam methane reforming
SOS	Save Our Surroundings
TNSP	transmission network service provider
TWh	terawatt hour/s
V2G	vehicle-to-grid

Abbreviation	Meaning
V2H	vehicle-to-home
VBN	Victorian Bioenergy Network
VFF	Victorian Farmers Federation
VPP	virtual power plant
VRE	variable renewable energy
WWF	World Wild Fund for Nature