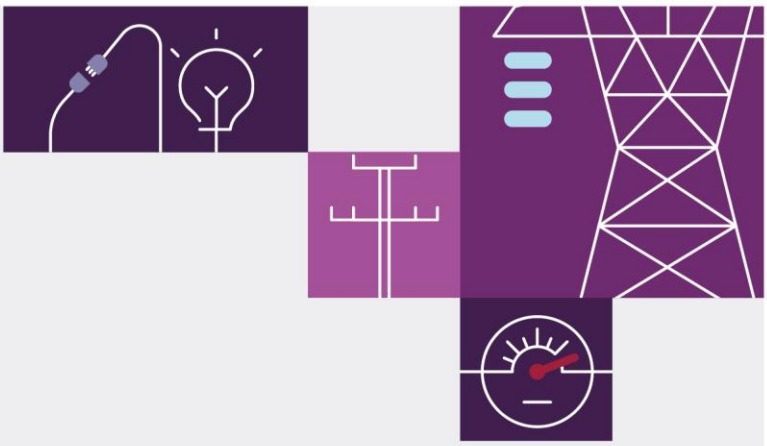
Draft 2022 Forecasting Assumptions Update

December 2021

Draft report for consultation

For use in the 2022 National Electricity Market Reliability Forecast



Important notice

Purpose

AEMO publishes this Draft 2022 Forecasting Assumptions Update pursuant to National Electricity Rules (NER) 4A.B.1(e) and the Australian Energy Regulator's Forecasting Best Practice Guidelines (FBPG). This report includes information on updated assumptions to apply in the Reliability Forecast (or other publications, as named in this report, for the National Electricity Market (NEM).

Disclaimer

AEMO has made all reasonable efforts to ensure the quality of the information in this publication but cannot guarantee that information, forecasts and assumptions are accurate, complete or appropriate for your circumstances. This publication does not include all of the information that an investor, participant or potential participant in the National Electricity Market might require, and does not amount to a recommendation of any investment.

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.

Version control

Version	Release date	Changes
1.0	20/12/2021	Initial release
1.1	21/12/2021	Revised release, adding additional detail in Section 2.2

Contents

Tables

Figures

Executive summary

AEMO delivers a range of forecasting and planning publications for the National Electricity Market (NEM), including the *Integrated System Plan* (ISP). Key inputs and assumptions for the ISP are published at least biennially as part of the *Inputs, Assumptions and Scenarios Report* (IASR). The most recent IASR, used to prepare the latest ISP, is the 2021 IASR.

Many of these same inputs and assumptions are also applied in preparing the reliability forecast in the NEM *Electricity Statement of Opportunities* (ESOO) and the *Gas Statement of Opportunities* (GSOO) supply adequacy assessment for eastern and south-eastern Australia, which are produced annually. To ensure these reports are as accurate as possible, particularly in the first few years, relevant inputs have been updated in this draft *Forecasting Assumptions Update* report (Assumptions Update) for consultation.

This report therefore complements the 2021 IASR, and uses the latest information available to update assumptions specifically relevant to near-term demand forecasting for the 2022 ESOO or the 2022 GSOO. It also includes updates from CSIRO's annual draft GenCost publication to allow for consultation on proposed changes in technology cost trajectories to inform that publication.

AEMO does not consider that any of these updates are sufficiently material to warrant an update to the latest ISP, which continues to be based on the 2021 IASR. The optimal development path in the Draft 2022 ISP has recently been published for consultation.

Notice of Consultation: Invitation for written submissions

Consultation on these updated inputs is following the single stage consultation process in accordance with Appendix B of the Australian Energy Regulator's (AER's) Forecasting Best Practice Guidelines.

All stakeholders are invited to provide a written submission to the questions outlined in this draft Assumptions Update, and on any other matter related to the updated assumptions. Submissions need not address every question posed and are not limited to the specific consultation questions contained in each chapter.

Submissions should be sent via email to forecasting.planning@aemo.com.au and are required to be submitted by **4 February 2022**. AEMO requests that, where possible, submissions should provide evidence that support any views or claims that are put forward.

The 2022 forecasting scenarios

AEMO applies four scenarios to forecast a range of plausible futures, including on key energy sector inputs such as the growth in demand for electricity, and in decentralisation as business and household consumers progressively transition to managing their own energy. Since the 2021 IASR, the scenario collection has been consolidated, removing the *Steady Progress* scenario and renaming the *Net Zero 2050* scenario *Progressive Change*, as outlined in the Draft 2022 ISP. In this draft Assumptions Update, AEMO has also renamed the *Hydrogen Superpower* scenario to *Hydrogen Export*, to enable potential future adjustment to the scale of development appropriate in that scenario to reflect a likely future.

Potential additional scenario

AEMO is considering a new fifth scenario – to replace the *Steady Progress* scenario – to capture the key drivers and outcomes that may be most relevant to the future needs and impacts on the natural gas industry and the eastern and south-eastern Australian gas network. Consultation with industry stakeholders has indicated interest in a scenario centring around use of existing gas infrastructure (pipelines, storages and end-use gas appliances) to distribute zero-carbon fuels such as green hydrogen and biogas.

AEMO is seeking stakeholder input to appropriately expand on this scenario narrative ahead of broader consideration on the possible scenario's input parameters.

This scenario will not be incorporated in the 2022 GSOO or 2022 ISP; however, it may influence future ISPs and GSOOs and will be co-designed with interested stakeholders in 2022.

Summary of updated assumptions

This draft Assumptions Update and associated draft 2022 *Forecasting Assumptions Update Workbook* (the Updated Assumptions Book) incorporates updates in data and forecasts, with particular focus on inputs of relevance to AEMO's 2022 supply adequacy forecasts.

It confirms the status and update method of some forecast components that use the latest actual data prior to applying scenario-based assumptions. Updated data inputs have provided for minor updates affecting distributed photovoltaics (PV), demand side participation (DSP) and liquefied natural gas (LNG) forecasts. It also provides updated assumptions for:

- Updated gas prices (based on forecasts to be used in the 2022 GSOO).
- Updated generation technology costs (based on the annual GenCost process led by CSIRO).

Next steps

Following the receipt of submissions by **4 February 2020**, AEMO may identify engagement opportunities for stakeholders before the completion of the consultation period and publication of the final Assumptions Update.

Further opportunities for engagement on inputs and assumptions are outlined throughout this report.

Details on how to get involved in the consultation process are provided on AEMO's website[1].

[1] At https://aemo.com.au/consultations/current-and-closed-consultations/2022-consultation-on-forecasting-assumptions-update.

1 Introduction

AEMO produces several publications that use a detailed set of inputs, assumptions and scenarios that are detailed in the Inputs, Assumptions and Scenarios Report (the IASR). These publications include the *Electricity Statement of Opportunities* (ESOO), the *Gas Statement of Opportunities* (GSOO), and the *Integrated System Plan* (ISP). These publications complement each other, providing adequacy assessments of the electricity and gas systems, as well as a whole of system plan that offers a vision for the optimal developments needed within the power system to provide energy consumers a path to a transformed reliable, low cost, net zero emissions future National Electricity Market (NEM).

AEMO uses a scenario analysis approach to investigate the various uncertainties facing the energy sector, to assess supply adequacy, and to identify the economically efficient level of infrastructure investment necessary to support the future energy needs of consumers in presence of uncertainty, and the risks of over- or under-investment.

This draft 2022 *Forecasting Assumptions Update* (Assumptions Update) outlines several updated inputs to be applied in future analysis, in particular the reliability forecast in the 2022 ESOO. This update meets AEMO's requirements to disclose and consult on basic inputs, and assumptions that underpin the reliability forecasts for the ESOO, in accordance with the principles of the Australian Energy Regulator's (AER's) Forecasting Best Practice Guidelines (FBPG). It is designed to complement the biennial *Inputs, Assumptions and Scenarios Report* (IASR), which provides the broader assumptions deployed across AEMO's forecasting and planning activities, including the ISP.

The information in this report is supported by the draft 2022 *Forecasting Assumptions Update Workbook* (the Updated Assumptions Book)[2], which provides more granular detail for the inputs and assumptions that are changing since the 2021 IASR.

All dollar values provided in this report are in real July 2021 Australian dollars unless stated otherwise.

1.1 Consultation process

Table 1 below summarises the consultation activities undertaken thus far for this draft Assumptions Update.

Table 1 Stakeholder engagement on the draft Assumptions Update

Activity	Date
CSIRO GenCost consultation	16 September 2021
Forecasting Reference Group (FRG) meeting	24 November 2021

The publication of this draft Assumptions Update commences the process of formal consultation on inputs appropriate for the reliability forecast in the 2022 ESOO, and stakeholders are invited to submit written feedback on any issues related to the draft Assumptions Update.

[2] Also at https://aemo.com.au/en/energy-systems/major-publications/integrated-system-plan-isp/2022-integrated-system-plan-isp/current-inputs-assumptions-and-scenarios.

Stakeholders are invited to provide input through a written submission to the questions outlined in this report. Submission should be sent via email to forecasting.planning@aemo.com.au and are required to be submitted by **Friday 4 February 2021**.

AEMO asks that submissions provide evidence that support any views or claims that are put forward.

Stakeholders should identify any parts of their submissions that they wish to remain confidential, and explain why the information provided is confidential. AEMO may still publish that information if it is otherwise authorised to do so, for example if the information is found to be available in the public domain, but will advise the stakeholder before doing so.

Following the completion of the submission window, AEMO will publish a summary of the issues raised across the submissions and outline how feedback is being, or has been, addressed, as well as publishing a final version of the Assumptions Update.

A more comprehensive consultation to update the biennial IASR will commence later in 2022, with a draft 2023 IASR due for publication in December 2022.

1.2 Supporting material

In addition to the draft Assumptions Update, Table 2 documents additional information related to AEMO's inputs and assumptions.

Table 2 Additional information and data sources

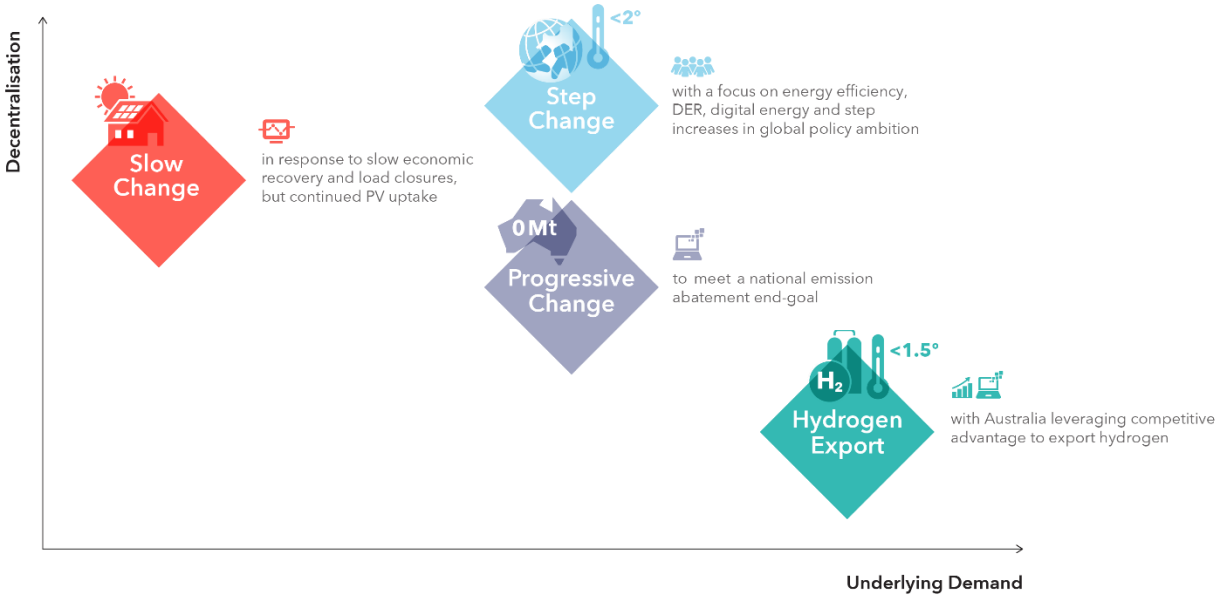
Organisation	Document/source	Link
Aurecon	2021 Cost and Technical Parameter Review	https://aemo.com.au/consultations/current-and-closed-consultations/2022-consultation-on-forecasting-assumptions-update
CSIRO	Draft GenCost 2021-22	https://doi.org/10.25919/k4xp-7n26 https://doi.org/10.25919/9f4c-w704
Lewis Grey Advisory	Lewis Grey Advisory Fuel Prices	https://aemo.com.au/consultations/current-and-closed-consultations/2022-consultation-on-forecasting-assumptions-update

1.3 Consolidating AEMO's scenarios in 2021 and 2022

The Draft 2022 ISP outlined four scenarios that will apply for the 2022 ISP. These represent a range of plausible futures, including on key energy sector inputs such as the growth in demand for electricity, and in decentralisation as business and household consumers progressively transition to managing their own energy. The scenarios are outlined in Figure 1.

Since the 2021 IASR, the scenario collection has been consolidated, removing the *Steady Progress* scenario and renaming the *Net Zero 2050* scenario *Progressive Change*, as outlined in the Draft 2022 ISP. In this draft Assumptions Update, AEMO has also renamed the *Hydrogen Superpower* scenario to *Hydrogen Export*, to enable potential future adjustment to the scale of development appropriate in that scenario to reflect a likely future.

Figure 1 2022 scenarios



AEMO is considering a new fifth scenario for consideration ahead of the draft and final 2023 IASR, 2023 GSOO, and 2024 ISP. This scenario would explore a future where greater access to low or zero emission molecular fuel sources (such as blended hydrogen, biogas or other constituent gases) delivered through the gas network can increase the potential role for molecules, rather than electrons, to reduce emission.

AEMO recognises that this represents a potential alternative to electrification for some energy consumers. AEMO will seek to engage with stakeholders in developing the appropriate settings that would apply in this scenario narrative, ahead of broader engagement for the 2023 IASR.

For example, the development of a low or zero emissions gas network may have similar emissions abatement objectives as *Step Change*, or could be most appropriate at the most ambitious emissions abatement settings for the scenarios which provides for rapid transformation to limit temperature rise to 1.5°C. With greater access to low or zero emissions gases, the scale of electrification and fuel-switching would naturally reduce, and investments in energy efficiency may slow, or speed up, as building upgrades may complement, or compete, with any gas appliance upgrades required to use the new cleaner fuel supply.

At this time, AEMO seeks stakeholder feedback on this preliminary scenario narrative, and whether it would be a valuable addition to AEMO's forecasting and planning scenario collection.

Matters for consultation

- Would a low-emissions gas-focused scenario complement the existing suite of scenarios for use in some or all of AEMO's forecasting and planning publications?
- What are the key drivers this scenario would incorporate, distinguishing it from the existing scenarios?

1.4 Alignment with update cycles for key inputs

In the Draft 2021 IASR, AEMO introduced the following input and assumptions classifications to distinguish between values near final and those that had not yet been updated through an annual update cycle:

- **Interim** – an input that has not been updated since the previous IASR (released in July) but is intended to be updated before the release of the final IASR.
- **Draft** – an input that is considered final unless AEMO receives sufficient evidence to change as part of the consultation.
- **Current view** – an input or assumption which is regularly updated in a standardised and objective process to reflect the most up-to-date observations; for example, metered demand data, or the continued development of new generation projects that are included within AEMO's Generation Information data set, or even environmental and energy policies that meet the commitment criteria.

In an attempt to strike an appropriate balance between the principles of transparency, stakeholder engagement and accuracy, AEMO presented interim values for many inputs and assumptions in the Draft 2021 IASR, and outlined the update and consultation processes proposed to ensure the most relevant, and up-to-date information is used at the time forecasts are performed. This included acknowledging which inputs would rely on consultant support to finalise, and outlining the opportunities to engage on these consultant outputs. Where indicative or interim values were used, they were clearly identified.

Stakeholders indicated that this approach limited their ability to provide constructive feedback on inputs that were only indicative or interim at the time of the formal consultation. While updated values were shared and discussed through Forecasting Reference Group (FRG) consultations, there was limited time and information available to engage deeply through this consultation process.

Having listened to this feedback, AEMO intends to limit the use of interim inputs and assumptions in future Draft IASRs and Assumption Updates. This means more of the forecast components (such as forecasts of future distributed energy resources [DER], multi-sectoral modelling and macro-economic forecasts) will be updated before publication of future Draft IASRs or Assumption Updates. This requires a shift in the timing of some annual update cycles, with more effort focused on updating inputs in the second half of the year, ahead of the formal consultation in December/January. While this may increase data latency risk for forecasting and planning publications that are not due until the following year, it is intended to strike a more appropriate balance between accuracy and transparency from a stakeholder perspective. Minor updates between Draft and Final IASR may still be explored in limited situations where an update is considered likely to improve forecast accuracy, particularly for reliability forecasts.

To allow for this change in timing of annual update cycles, only inputs likely to materially impact the forecast performance for the upcoming 2022 ESOO and 2022 GSOO have been updated through this draft Assumptions Update process. All other inputs, as reported in the 2021 IASR, are considered "draft" for the purpose of this consultation; that is, they are considered final and will not be updated prior to preparing the 2022 ESOO reliability forecasts unless AEMO receives sufficient evidence to change as part of this consultation. In the rare situation where interim values have been used in this draft Assumptions Update, they have been clearly identified.

2 Updated assumptions

2.1 Consumption and demand: historical and forecasting components

AEMO uses a range of historical data to train and develop its models, and forecast input data series (component forecasts) to project future outcomes using these models.

Historical components are updated at varying frequencies, from live metered data to monthly, quarterly, or annual batch data. Key historical data includes:

- Operational demand meter reads.
- Estimated network loss factors.
- Other non-scheduled generators.
- Distributed PV uptake.
- Gridded solar irradiance, and resulting estimated distributed PV normalised generation.
- Weather data (such as temperature and humidity levels).

AEMO updates its projections of energy consumption and demand at least annually[3], and includes significant stakeholder engagement through the FRG, industry engagement via surveys, consultant data and recommendations, and AEMO's internal forecasting of each sector and sub-sector affecting energy consumption and peak demands.

Table 3 Status and update process for key inputs and assumptions[4]

Input	Current status	Forward plan for updating inputs and assumptions
Consumption and demand historical and forecasting components		
Historical data	Current view	Updated when available
Distributed PV	Draft	All draft inputs are considered final unless AEMO receives sufficient evidence to change as part of this draft Assumptions Update consultation. Where practical, AEMO may re-base the input with the latest historical data to improve accuracy for the first forecast year.
Battery storage uptake and virtual power plant (VPP) aggregation	Draft	
Electric and fuel-cell vehicles	Draft	
Electrification of other sectors	Draft	
Economic and population, including connections	Draft	
Energy efficiency	Draft	
Appliance uptake and fuel switching	Draft	
Electricity prices	Draft	

[3] Updated forecasts within a year can be issued in case of material change to input assumptions.

[4] AEMO's website provides up-to-date engagement opportunities, which may supersede this publication: https://www.aemo.com.au/energy-systems/major-publications/integrated-system-plan-isp/2022-integrated-system-plan-isp/opportunities-for-engagement.

Input	Current status	Forward plan for updating inputs and assumptions
Industrial load forecasts	Interim	Industrial load forecasts (excluding liquefied natural gas [LNG]) considered Interim, will be sourced via participant surveys conducted in April 2022 to use latest information possible. Updated LNG forecasts considered Draft, have been guided by stakeholder surveys, and consulted upon in the November 2021 FRG Any further updates will be based on feedback on this draft Assumptions Update. Scheduled for FRG discussion in May 2022.
Demand side participation	Interim	Considered interim, and will be updated based on an analysis of 2021-22 summer behaviour, and supported by the DSP Information Portal. The portal is updated by all market participants in April 2022. Preliminary DSP outcomes scheduled for FRG discussion in May 2022.

Distributed energy resources

Input classification	Draft
Input vintage	Updated forecast finalised in November 2021.
Source	CSIRO Green Energy Markets Clean Energy Regulator Australian Photovoltaic Institute AEMO's DER register
Updates since 2021 IASR	PV model rebased with updated distributed PV actual installations

DER describes consumer-owned devices that, as individual units, can generate or store electricity or have the 'smarts' to actively manage energy demand. This includes small-scale embedded generation such as distributed PV systems (including PV non-scheduled generation [PVNSG]), battery storage, and EVs. As outlined in the 2021 IASR, AEMO engaged CSIRO[5] and Green Energy Markets (GEM)[6] to prepare independent forecasts of this important component. With two forecasts, using two independent models but aligned to the same assumptions and scenario narratives, AEMO considers that the accuracy of the forecasts are improved over a single view.

Distributed PV

Current distributed PV installed capacity estimates are from the Clean Energy Regulator (CER), with the DER Register now providing additional data to supplement the CER data. PVNSG installed capacity estimates are provided by the Australian Photovoltaic Institute (APVI), in the first instance, then supplemented by the CER and DER Register.

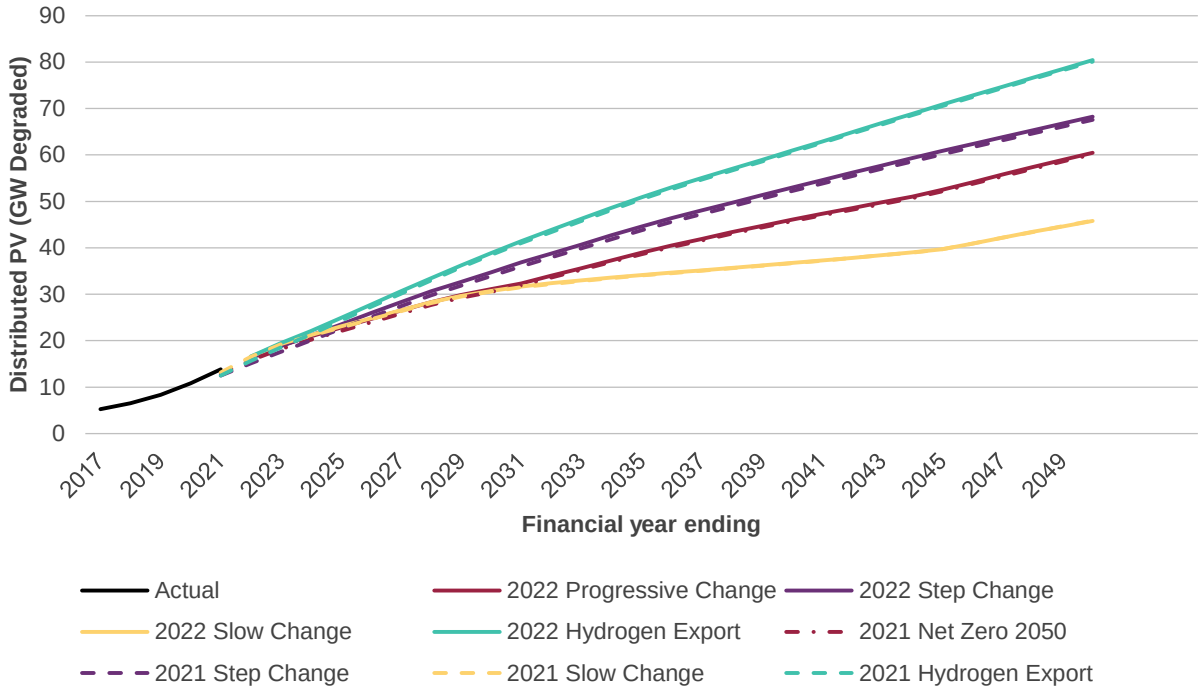
AEMO proposes to continue to apply the projected distributed PV uptake rate from the 2021 IASR in 2022, rebased to reflect current installations. This draft Assumptions Update demonstrates a rebased forecast using the latest estimate of total installed capacity of distributed PV systems in the NEM from the most recent CER release, which is **13.8 gigawatts (GW)** as of October 2021. This may be rebased again to reflect current view at the time the 2022 ESOO modelling commences.

[5] See CSIRO: *Projections for small-scale embedded technologies*, at https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/inputs-assumptions-methodologies/2021/csiro-der-forecast-report.pdf.

[6] See Green Energy Markets: *Projections for DER – solar PV and stationary energy battery systems*, at https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/inputs-assumptions-methodologies/2020/green-energy-markets-der-forecast-report.pdf.

Details on CSIRO's and GEM's forecasting approach and outlook can be found in each consultant's report, referenced above.

Figure 2 NEM distributed PV installed capacity (degraded)



Large industrial loads (LILs)

Input classification	Draft
Input vintage	LNG component of LIL forecast updated in October 2021
Source	Interviews/Surveys Economic Outlook Media search/announcements
Updates since 2021 IASR	Updated based on new survey data provided by large customers. The scenario differences have been adjusted to reflect finalised scenarios.

AEMO segments and forecasts LILs separately to small and medium commercial enterprises, due to both their significance in the overall scale of energy consumption, and the individual business circumstances that may not be appropriately captured in broader econometric models.

AEMO currently sources information regarding LILs from:

- Surveys and interviews of the largest consumers, considering the economic outlook based on the advice provided to AEMO by BIS Oxford Economics.
- AEMO's standing data requests from distribution network service providers (DNSPs) regarding prospective and newly connecting loads.
- Media searches and company announcements.

The updated LIL forecast includes updated LNG forecasts, informed by recent survey data from the LNG consortia provided to support the 2022 GSOO, as detailed in the following sub-section.

Liquified natural gas

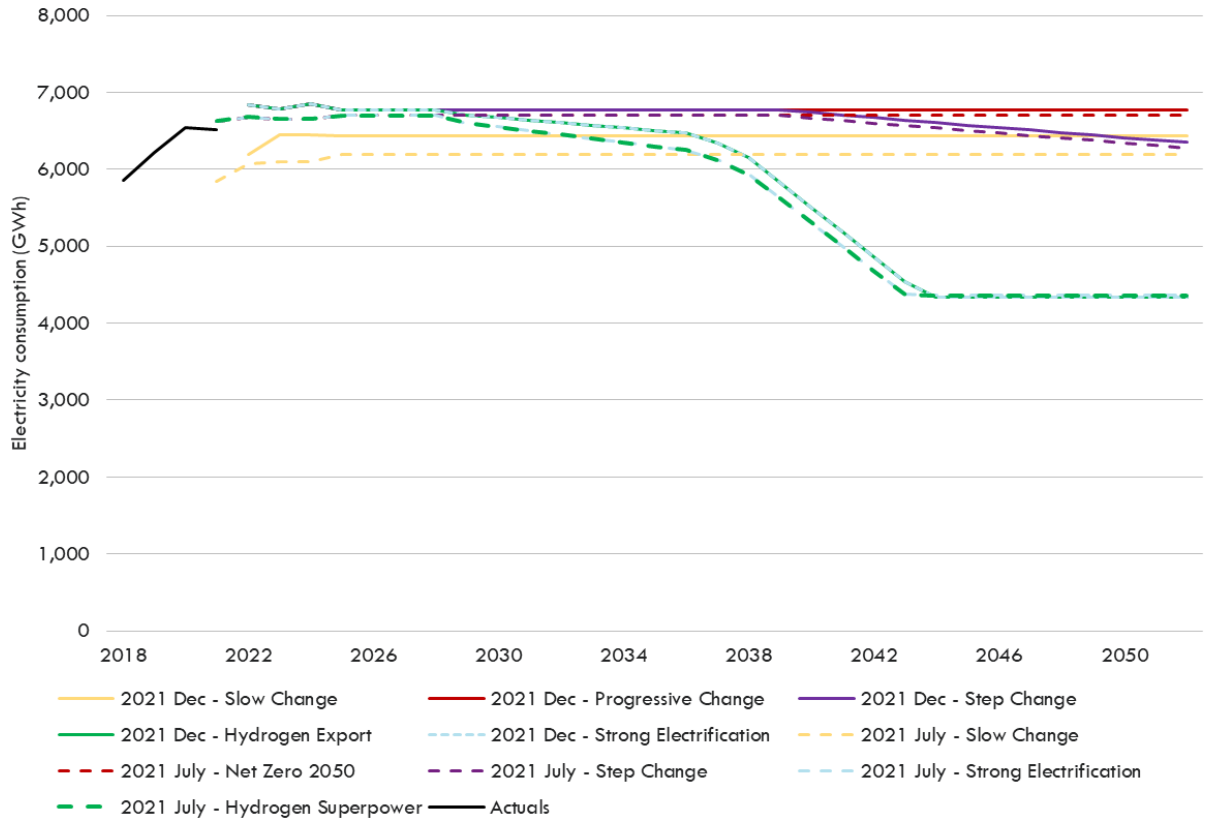
Queensland's LNG industry is a material contributor of existing industrial electricity loads, consuming approximately 5% of AEMO's total business consumption category.

The international LNG market faces an uncertain future. Global demand for liquid fuels shifts as each country determines how it will achieve its own emissions reduction commitments, with some commentators predicting ongoing strong growth through to 2050, while others predicting a notable decrease[7]. For the NEM's LNG exports facilities in Queensland, AEMO considers that market conditions are unlikely to be conducive to any major new infrastructure to increase export capacity – and the existing LNG export facilities already operate at high utilisation factors. AEMO therefore considers that the upper range of reasonable forecasts for LNG operations is for operations to continue at current high utilisation levels.

The LNG forecasts estimate the expected electricity consumption of the operations of coal seam gas (CSG) fields in the NEM by considering surveyed data provided by the LNG consortia, as per other LILs. This data considers the anticipated operating range of CSG facilities over the short term, between three and five years ahead.

Figure 3 demonstrates the forecast range across AEMO's scenario collection. This draft Assumptions Update incorporates the updated LNG consortia forecast, resulting in a minor increase compared to the 2021 IASR forecast.

Figure 3 LNG forecast electricity consumption, by scenario



[7] The International Energy Agency outlined an uncertain future for LNG; see International Energy Agency (2021), *Net Zero by 2050: A roadmap for the Energy Sector*, at https://www.iea.org/reports/net-zero-by-2050.

Demand side participation

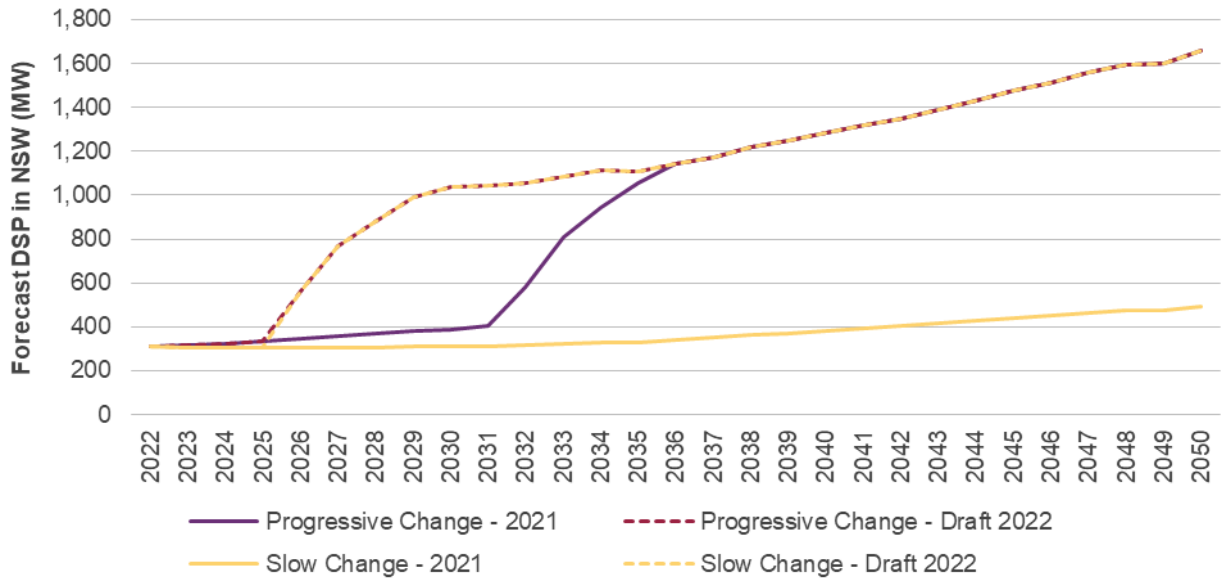
Input classification	Interim
Input vintage	Forecast in June 2021.
Source	Historical meter data analysis and information submitted to the DSP Information Portal in April 2021. Information about policy driven programs.
Updates since 2021 IASR	New South Wales Peak Demand Reduction Scheme is included in all scenarios as now considered formally committed[8].
Update process	Forecast DSP will be updated in based on information submitted to the DSP Information Portal in April 2022 and historical meter data analysis.

AEMO's forecast approach considers DSP explicitly in its market modelling, meaning that demand forecasts reflect what demand would be in the absence of DSP to avoid double counting. The forecast for DSP in the upcoming year is produced following AEMO's *Demand Side Participation Forecast Methodology*[9].

The longer-term growth in DSP is assumption-driven. One change since the 2021 IASR is that the New South Wales Peak Demand Reduction Scheme (PDRS) is now considered committed. The scheme is therefore included in all scenarios, starting in 2022-23 with the target growing to 10% of peak demand by 2029-30 and then staying flat. The scheme has an impact on the summer target only. The impact on DSP considers that part of the PDRS target will be delivered through energy efficiency and battery storage initiatives, which is accounted for separately in AEMO's forecast components. Accordingly, the growth in DSP is scaled down to match.

The impacts on the forecast DSP in New South Wales for the two scenarios that did not include the PDRS in the 2021 IASR forecast are shown in Figure 4.

Figure 4 Impact of including the PDRS with 10% target by 2030 in the Slow and Progressive Change scenarios



[8] See https://www.energy.nsw.gov.au/government-and-regulation/energy-security-safeguard/peak-demand-reduction-scheme.

[9] At https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2020/demand-side-participation/final/demand-side-participation-forecast-methodology.pdf.

2.2 Existing generators and transmission

AEMO uses a range of data to describe the existing generators in its models. Some of this data is updated through established processes and documented methodologies as outlined in Table 4 below.

Table 4 Status and update process for key inputs and assumptions for existing generation and transmission

Input	Current status	Forward plan for updating inputs and assumptions
Consumption and demand historical and forecasting components		
Generation Information data	Current view	Updated quarterly based on AEMO's Generation Information survey and is published on AEMO's Generation Information website[10]. This data is collected and published in accordance with the Generation Information Guidelines[11].
Marginal loss factors (MLFs), inter-regional loss flow equations and loss proportion factors	Current view	Initial MLFs, loss equations and proportioning factors are based on the most recent Regions and Marginal Loss Factors report[12]. Loss equations and proportioning factors are varied based on flow path augmentations, as outlined in the ISP Methodology[13]
Scheduled generator forced outage rates	Interim view	The interim view will be updated based on historical and forward-looking forced outage rates to be provided by registered participants in accordance with AEMO's Standing Information Request[14]. The data is collected in April 2022 and thus accounts for generator performance over the 2021-22 summer. Based on the methodology outlined in the ESOO and Reliability Forecast Methodology[15], AEMO will calculate new generator forced outage rates for all scheduled generators. The forced outage rates are scheduled for FRG Consultation in June 2022.
Forced outages affecting inter-regional power transfers	Interim view	AEMO updated its approach to modelling forced outage rates for transmission elements affecting inter-regional power transfers as result of the consultation of the 2020 Forecast Improvement Plan[16]. AEMO will engage with stakeholders through FRG consultation on the approach scheduled for January 2022, while the resulting forced outage rates are scheduled for FRG Consultation in June 2022.

2.3 New entrant generator assumptions

Technology build costs

Input classification	Draft
Input vintage	Updated through 2021-22 GenCost process.
Source	CSIRO: GenCost 2021-22 Draft report Aurecon: 2021 Costs and Technical Parameters Review Entura: 2018 Pumped Hydro Cost Modelling

[10] At https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/forecasting-and-planning-data/generation-information.

[11] At https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/generation_information/final-generation-information-guidelines.pdf.

[12] Available at https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/market-operations/loss-factors-and-regional-boundaries.

[13] At https://aemo.com.au/-/media/files/major-publications/isp/2021/2021-isp-methodology.pdf.

[14] The 2022 Standing Information Request is due late January and will be published at: https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/forecasting-and-reliability/standing-information-requests

[15] At https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/nem_esoo/2021/esoo-and-reliability-forecast-methodology-document.pdf.

[16] At https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2020/forecast-improvement-plan/forecast-improvement-plan-2020.pdf.

	Hydro Tasmania information on Cethana project
Updates since 2021 IASR	Updated to reflect updated projections from Aurecon and CSIRO, which includes revisions based on stakeholder feedback.
Update process	Feedback to this consultation will explicitly inform the finalisation of the GenCost 2021-22 report.

Capital cost trajectories

Generator capital cost trajectories are informed by the GenCost publication, an annual publication of electricity generation technology cost projects conducted jointly through a CSIRO/AEMO partnership. To support this forecast, Aurecon determined the current cost of each generation technology.

The GenCost projections utilise CSIRO's GALLM model, which provide build cost forecasts that are a function of global and local technology deployment.

The GenCost scenarios have evolved to better reflect the uncertainty in the speed of global emissions reduction, which improves the alignment with AEMO's scenarios.

The build cost projections are given for three GenCost scenarios ("Global NZE by 2050", "Global NZE post 2050" and "Current policies"). These scenarios are described in greater detail in CSIRO's GenCost Draft report[17], and AEMO maps the 2022 scenarios to the GenCost scenarios, as shown in Table 5 below. The scenario mapping of GenCost scenario to 2022 scenario reflects what AEMO considers to be the greatest fit to the narratives of AEMO's scenario collection:

- *Step Change* will apply GenCost's Global NZE post 2050 scenario, which is consistent with a 1.7° world and medium-high electrification.
- *Hydrogen Export* will apply GenCost's Global NZE by 2050 scenario, given they both apply strong decarbonisation ambitions, driving towards net zero emissions by 2050, with high levels of VRE development
- *Slow Change* and *Progressive Change* will apply GenCost's Current Policies scenario, which does not significantly expand renewable targets and has a more muted decarbonisation ambition.

While *Progressive Change* does increase its emissions reduction ambition, achieving net zero emissions by 2050, the scenario also delays significant action to align with a higher warming future. As such, it more aligns with Current Policies' 2.6 degree warming future.

Figure 5 and Figure 6 present GenCost's Global NZE post 2050 build cost projections for selected technologies if constructed in Melbourne, excluding connection costs, as examples. Cost projections for each technology and scenario are available in the Updated Assumptions Book.

Table 5 Mapping AEMO scenario themes to the GenCost scenarios

AEMO scenario	GenCost scenario	Explanation
Slow Change	Current Policies	Consistent with existing (mid 2021) commitments to the Paris Agreement, leading to the lowest global emissions reduction ambition and a 2.6 degree warming future.
Progressive Change	Current Policies	
Step Change	GenCost Global NZE post 2050	Consistent with global action to limit temperature rises to less than 2 degrees, and with industrialised countries targeting net zero emissions by 2050.

[17] At https://publications.csiro.au/publications/publication/PIcsiro:EP2021-3374.

AEMO scenario	GenCost scenario	Explanation
Hydrogen Export	GenCost Global NZE by 2050*	The most ambitious global emissions reduction scenario, consistent with limiting temperature rises to less than 1.5 degrees, as well as a strong focus on electrification and hydrogen-based developments.

*The Hydrogen Export scenario assumes more accelerated capital cost reductions for large-scale Solar PV compared to the Global NZE by 2050 GenCost scenario, as a key enabler of hydrogen expansion for export.

Figure 5 Global NZE post 2050 build cost trajectories forecast, scenarios, wind and solar

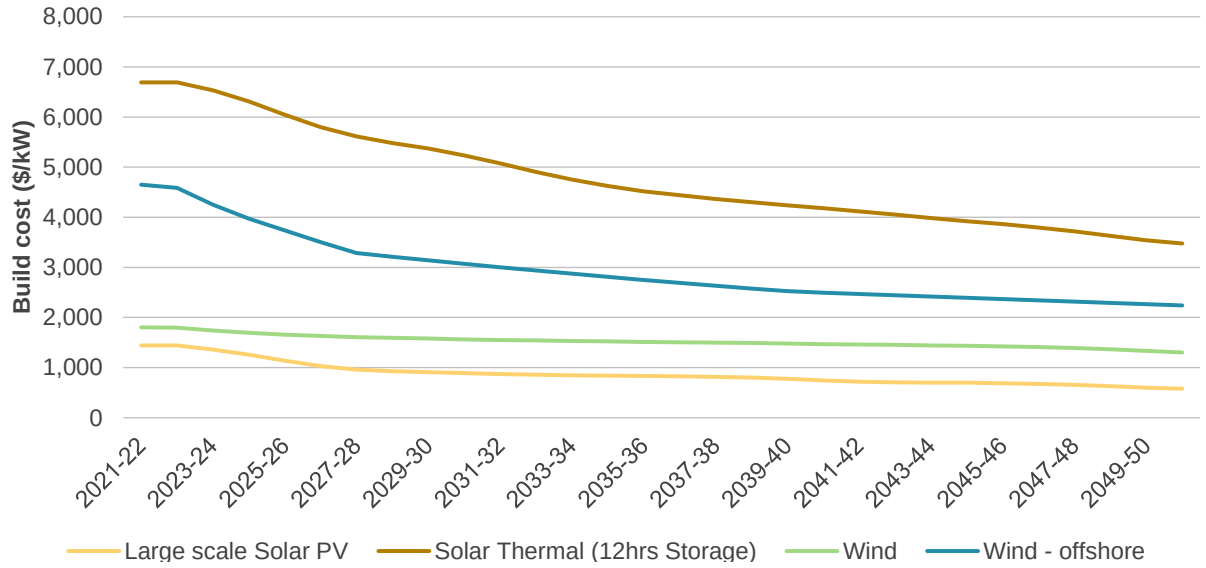
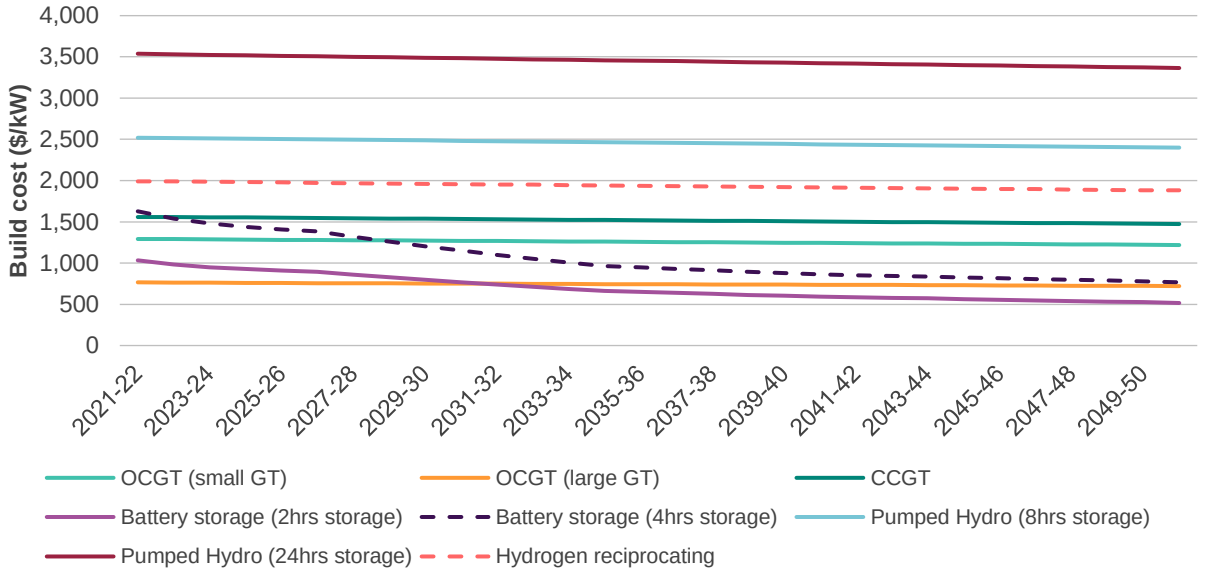


Figure 6 Global NZE post 2050 build cost trajectories forecast, gas, and selected storage



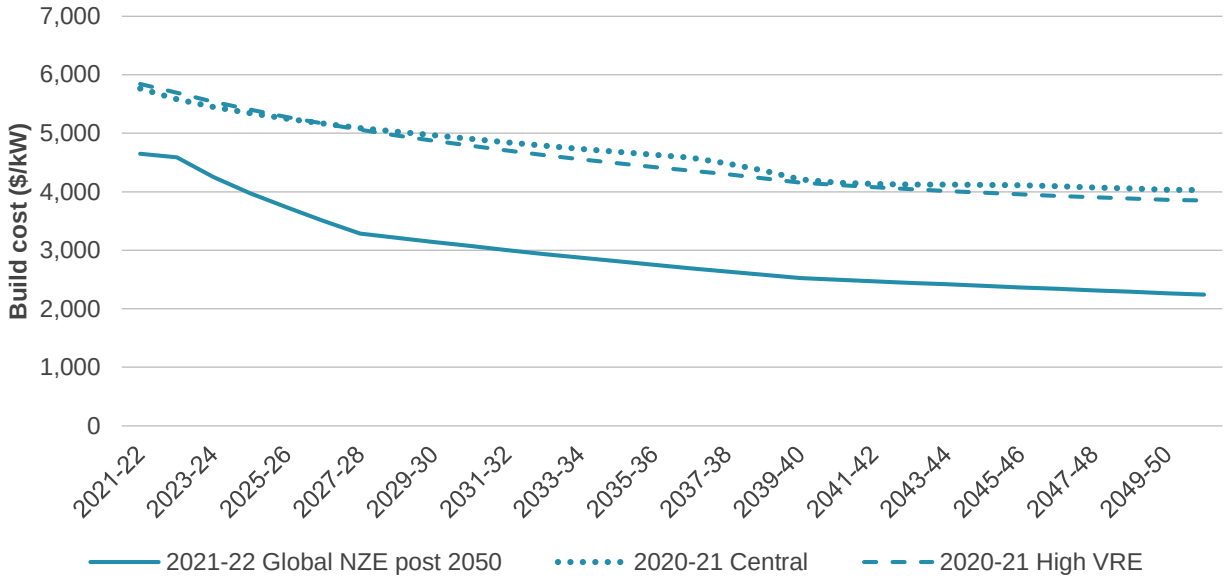
Offshore wind is the technology that exhibits the biggest difference in starting capital cost, and cost reduction across the horizon, compared to the 2020-21 GenCost projections adopted in the 2021 IASR. This is largely due to observed cost reductions in projects being delivered globally. Compared to many of the other technologies, however, there remains more uncertainty on the costs of projects delivered in Australia given the lack of any completed projects. Furthermore, the maturity of other supporting assumptions is not as advanced. This includes

for example, considerations of site availability in locations suitable for fixed offshore wind (depths below 60 metres).

Further refinement of offshore wind assumptions will be progressed over the next year; considering this uncertainty, AEMO considers that it is premature to wholly apply this updated assumption to the 2022 ISP despite the improvement in cost trajectory for this technology. Instead, AEMO will introduce an additional ISP sensitivity to understand if the draft optimal development path would be materially different if offshore wind costs were to reduce significantly. Similarly, the next GenCost process will consider the inclusion of cost projections for floating offshore wind.

Figure 7 shows the offshore wind build cost trajectory for CISRO's 2021-22 Global NZE post 2050 scenario compared to the 2021 IASR assumptions (from the 2020-21 GenCost).

Figure 7 Wind – offshore build cost trajectories forecast by GenCost scenario



Technology cost breakdowns

Input classification	Draft
Input vintage	Updated through 2021-22 GenCost process for technology cost breakdown.
Source	GHD: 2018-19 Costs and Technical Parameters Review Aurecon: 2021 Costs and Technical Parameters Review AEMO revisions
Updates since 2021 IASR	Updated technology cost breakdown from 2021 Aurecon data

To calculate the capital costs of technologies developed in different locations, the locational cost factors provide a multiplicative scalar to the respective generation and storage development component costs (equipment, fuel connection, land and development, and installation). These scalars are derived from regional development cost weightings by cost component, and technology cost component breakdowns, which are presented in Table 5. This draft Assumptions Update captures updated technology cost component breakdowns, informed by updated data from the 2021-22 GenCost process.

The Updated Assumptions Book provides additional details of these cost factors, including the resulting technology, regional cost adjustment factors.

Table 6 Technology cost breakdown ratios

Technology	Equipment costs	Fuel connection costs	Cost of land and development	Installation costs
Black Coal (advanced ultra supercritical PC)	33%	0%	17%	50%
Black Coal (advanced ultra supercritical PC) with CCS	30%	0%	26%	44%
OCGT (small GT)	60%	6%	8%	26%
OCGT (large GT)	58%	10%	7%	25%
Hydrogen based reciprocating engines	55%	0%	8%	37%
CCGT	62%	3%	8%	27%
CCGT with CCS	57%	3%	16%	24%
Biomass	33%	0%	17%	50%
Battery storage (1hr storage)	76%	0%	9%	15%
Battery storage (2hrs storage)	77%	0%	7%	16%
Battery storage (4hrs storage)	79%	0%	4%	16%
Battery storage (8hrs storage)	81%	0%	2%	17%
Large-scale solar PV	57%	0%	6%	38%
Solar thermal (12hrs Storage)	75%	0%	0%	25%
Wind	68%	0%	3%	29%
Wind – offshore	69%	0%	2%	29%

Technical and other cost parameters (new entrants)

Input classification	Draft
Input vintage	Being updated through 2021-22 GenCost process
Source	Aurecon: 2021 Costs and Technical Parameters Review GHD: 2018-19 Costs and Technical Parameters Review Hydro Tasmania information on Cethana project
Updates since 2021 IASR	CSIRO Draft GenCost 2021-22
Update process	Any further updates will be based on feedback on this draft Assumptions Update and the CSIRO's draft GenCost 2021-22 consultation.

Technical and other cost parameters for new entrant generation and storage technologies include:

- Unit size and auxiliary load.
- Seasonal ratings.
- Heat rate.
- Scope 1 Emissions factors.
- Minimum stable load.

- Fixed and variable operating and maintenance costs.
- Maintenance rates and reliability settings.
- Lead time, economic life, and technical life.
- Storage parameters (including cyclic efficiency and maximum and minimum state of charge).

These parameters for new entrant technologies are updated as part of the annual GenCost scope of work to reflect the current trends and estimates of future cost and performance data of new technologies. These are published in the Updated Assumptions Book and in the supporting material from Aurecon.

Storage modelling

Input classification	Draft
Input vintage	Being updated through 2021-22 GenCost process, and augmented with additional data provide by Hydro Tasmania in June 2021.
Source	Aurecon: 2021 Costs and Technical Parameters Review CSIRO: GenCost 2021-22 Final report Entura: 2018 Pumped Hydro Cost Modelling Hydro Tasmania information on Cethana project
Updates since 2021 Final IASR	CSIRO Draft GenCost 2021-22

Batteries

Large-scale battery expansion candidates are modelled with fixed power to energy storage ratios, but with flexibility to charge and discharge to achieve the optimal outcome for the system within the fixed power to energy storage ratio limit.

Assumptions for battery storages of 1-hour, 2-hour, 4-hour, and 8-hour duration depths are based on data provided by Aurecon in their latest report. This draft Assumptions Update has lowered the annual battery degradation rate, from 2.2% per annum in the 2020-21 GenCost dataset, to 1.8% annually, reflecting recent observations. While AEMO does not model this factor explicitly in the capacity outlook model used in ISP modelling, AEMO reduces the storage capacity of all battery storage by 16% which is an estimate of the average storage capacity over the battery life. The 2021 IASR assumption applied a 19% reduction. This is not considered a sufficiently material factor to adjust for the 2022 ISP.

Solar thermal technology

AEMO models solar thermal as a solar thermal central receiver with integrated energy storage. This draft Assumptions Update has expanded that storage, from 8 hours to 12 hours, to better represent recent Australian project developments.

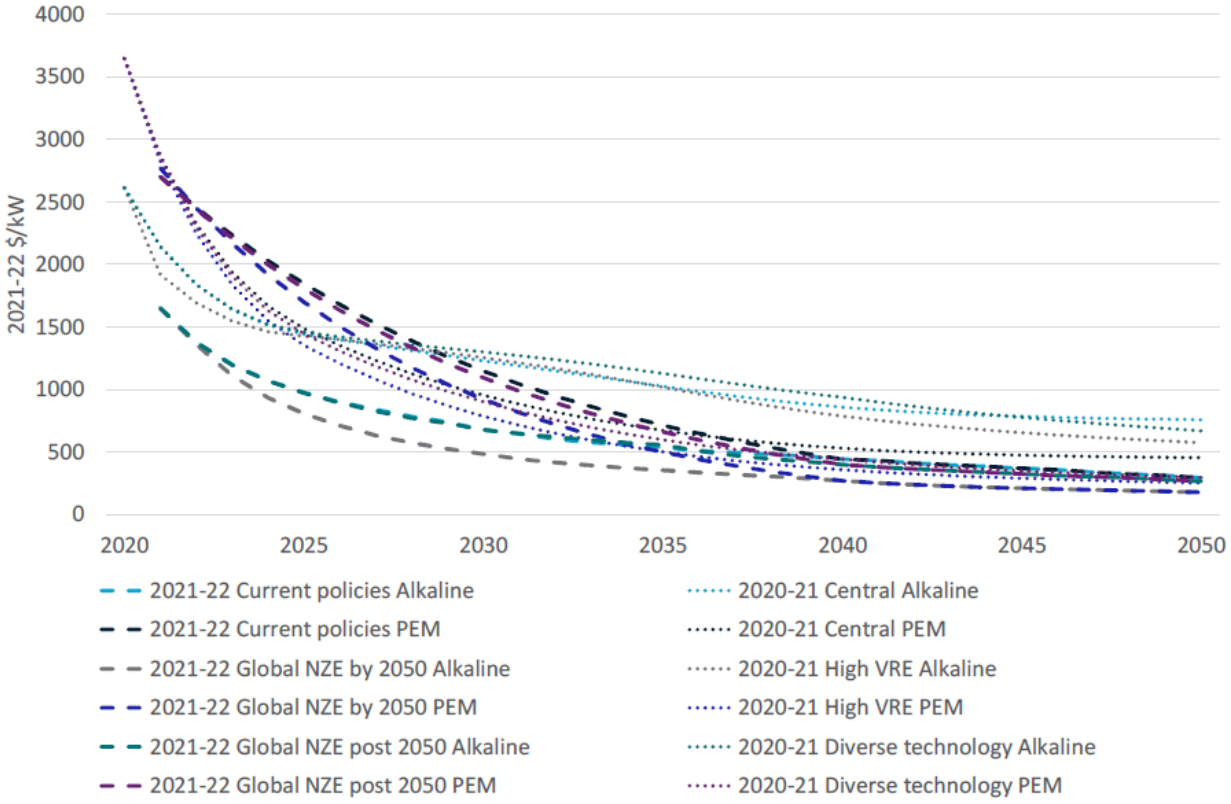
2.4 Other technology costs

Electrolyser costs

Input classification	Draft
Input vintage	Being updated through 2021-22 GenCost process
Source	Aurecon: 2021 Costs and Technical Parameters Review
Updates since 2021 IASR	CSIRO Draft GenCost 2021-22
Update process	Any further updates will be based on feedback on this draft Assumptions Update and the CSIRO's draft GenCost 2021-22 consultation.

The CSIRO GenCost 2021-22 report contains estimates for the forecast costs for electrolysers, including proton exchange membrane (PEM) and alkaline technologies. Hydrogen electrolyser deployment is presently being supported by trials both globally and in Australia. This may lead to cost reductions through time as electrolyser manufacturing scales up. The 2021-22 GenCost captures this emerging technology, with cost reductions associated initially with Alkaline technology relative to 2020-21 GenCost. PEM technology costs are similar to 2020-21 forecast costs, and published in the Updated Assumptions Book. Comparisons between the 2020-21 GenCost and 2021-22 GenCost are reproduced in Figure 8 below.

Figure 8 Electrolyser technology costs, CSIRO GenCost comparison[18]



[18] Sourced from GenCost 2021-22, available at: https://publications.csiro.au/publications/publication/PIcsiro:EP2021-3374.

2.5 Fuel price assumptions

Gas prices

Input classification	Draft
Input vintage	December 2021
Source	Lewis Grey Advisory
Updates since 2021 IASR	Updated gas prices from Lewis Grey Advisory consultancy, consulted upon in November 2021 FRG

AEMO sourced natural gas price forecasts from consultant Lewis Grey Advisory (LGA). These gas prices were updated in December 2021, for the 2022 GSOO report.

Gas price forecasts are derived from a game theory model that simulates competitive pricing outcomes suitable to understand contract pricing[19]. Gas production costs, reserves, infrastructure, and pipeline tariffs are fundamental inputs into this model that also considers international natural gas prices, oil prices, and measures of the domestic economy. The methodology was presented at the FRG in November 2021[20], and the assumptions are detailed in the LGA report (a supporting reference material to this draft Assumptions Update consultation).

Several improvements to methodology and inputs (as listed in Table 7) have also been implemented considering stakeholder feedback from the previous LGA forecast. Specifically, projected pipeline transmission costs now consider the influence of falling gas demand, and forecasts of gas prices for gas-fired generation now consider the regional load factors of these generators and have been benchmarked against the July 2021 Gas Inquiry interim report, published by the Australian Competition and Consumer Commission[21].

Table 7 Improvements applied to gas price forecasts

Changes from July 2021	Variable description	Method applied
Gas transmission costs	Transmission costs to the relevant gas transmission node is the cost of shipping gas from one node to another.	Estimated transmission costs are now indexed to the inverse of estimated gas demand to reflect the fixed cost nature of gas infrastructure.
Regional load factors applied in gas-powered generation gas prices	A generator's load factor is a measure of the utilisation rate, or efficiency of electrical energy usage. A gas-fired generator's load factor varies across each year between peak and non-peak periods.	Wholesale prices for gas-fired generators is adjusted by applying the load factor of each GPG region, this is estimated by usage during winter peak periods, as it is forecast in the 2021 GSOO.
Forecasts benchmarked against ACCC most recent published prices	LGA's model now benchmarks its gas pricing model against contract prices reported by the ACCC in the Gas Inquiry 2017-2025 Interim Report, July 2021.	Benchmarking is done by replicating Eastern Australia gas market conditions before these contracts were entered. LGA tests this by applying its model without any prior domestic contracts in 2021 (but assuming export contracts were in place) and with contract durations of one year.

Six gas price forecasts were provided, based on assumptions about gas reserves, international gas pricing, Australian infrastructure, cost of producing gas from existing and upcoming petroleum fields, and the local level of

[19] The price projections do not attempt to model the full variance of the spot market. The spot market can sometimes experience pricing at very high levels when there is little uncontracted gas available and sometimes at very low levels, even below breakeven, when there is a surplus of uncontracted gas available.

[20] AEMO. FRG minutes and meeting packs, at https://aemo.com.au/en/consultations/industry-forums-and-working-groups/list-of-industry-forums-and-working-groups/forecasting-reference-group-frg.

[21] ACCC, Gas inquiry July 2021 interim report, at https://www.accc.gov.au/publications/serial-publications/gas-inquiry-2017-2025/gas-inquiry-july-2021-interim-report.

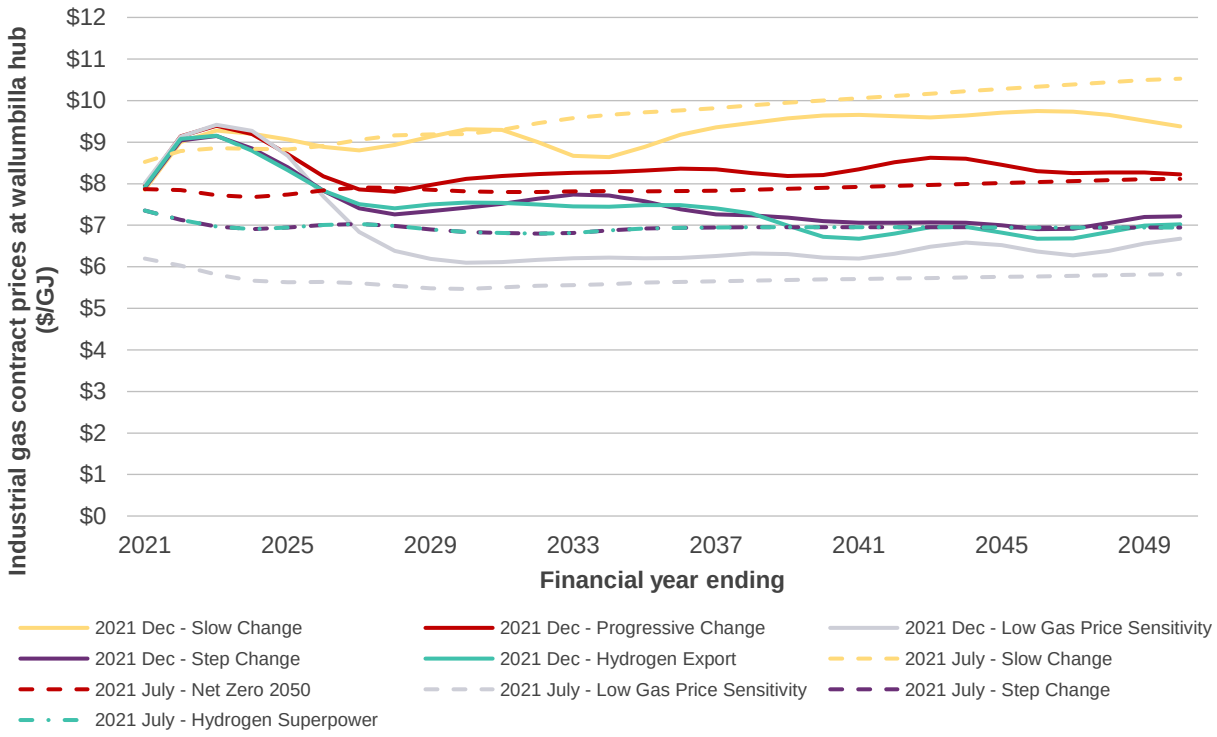
competition. For all trajectories, no explicit reservation policy was considered, and it is assumed that the committed Port Kembla Gas Terminal would have the capability to import LNG into Australia from winter 2023 onwards.

In a Low Gas Price sensitivity, LGA assumes new gas fields will be developed for the Gunnedah, North Bowen, Galilee and Beetaloo gas basins with additional pipeline infrastructure to connect these gas basins to the Eastern Australia gas market from 2023.

Gas prices for gas-fired generators are provided in the Updated Assumptions Book. The costs include regional pricing, considering the supply options and the relevant cost of pipeline transmission. They also apply a further adjustment based on pipeline transmission to the actual generation plant, and influence of contracts. These factors, and the improvements mentioned previously, drive the difference in outcomes to the previous 2021 IASR forecasts.

Figure 9 presents a gas price comparison for industrial consumer prices, measured at Wallumbilla, comparing the updated forecast with the previous, within the 2021 IASR. Other consumer types, such as gas generation users, are within the Updated Assumptions Book.

Figure 9 Average industrial gas price forecast at Wallumbilla



These updated gas prices are considered to be immaterial to the outcomes of the Draft 2022 ISP. The forecasts include both minor increases and decreases relative to the 2021 IASR, rather than a consistent trend or forecast correction. As gas-fired generation is typically the highest cost of dispatchable generators, these changes will not likely have any material consistent implication for generator operations and new gas developments. Further, the gas price sensitivity within the Draft 2022 ISP demonstrated that a significant reduction in gas price does not materially impact the optimal development path. As such, it will not be used for the Final 2022 ISP publication.

Matters for consultation

- Do you have any feedback on the updated technology cost assumptions relating to new technologies, as described in this report or the referred Draft GenCost 2021-22 report?
- Do you have any feedback on the assumed gas price trajectory?