Consultation Paper on key Forecasting inputs in 2020

December 2019

Important notice

PURPOSE

The publication of this Consultation Paper commences AEMO's consultation on AEMO's key inputs and assumptions for use in its 2020 Forecasting publications for the National Electricity Market (NEM).

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This Consultation Paper includes the information required by clause 5.20.1(a) of the National Electricity Rules and addresses the requirements of the Australian Energy Regulator's Draft Forecasting Best Practice Guidelines.

This publication has been prepared by AEMO using information available at 12 December 2019.

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VERSION CONTROL

Version	Release date	Changes
1	12/12/2019	
1.1	24/12/2019	Minor editorial corrections.

Executive summary

AEMO delivers a range of planning and forecasting publications for the National Electricity Market (NEM), including the NEM Electricity Statement of Opportunities (ESOO) and the Integrated System Plan (ISP).

AEMO has prepared this Consultation Paper to provide information and seek stakeholder submissions on inputs and assumptions for AEMO's 2020 forecasting and planning publications, including but not limited to feedback on:

- Changes required to key inputs and assumptions used in AEMO's 2019 NEM planning and forecasting publications that affect AEMO's supply and demand forecasting models used in preparing the ESOO.,

- CSIRO's latest GenCost 2019-20 Draft Report which provides an annual update to generation technology costs.

- New gas price forecasts prepared by Core Energy, December 2019.

AEMO seeks feedback from all interested parties on the variations in current inputs and assumptions that should apply in AEMO's 2020 forecasting and planning activities.

Questions are presented in the chapters of this report where AEMO is seeking evidence-based commentary and guidance. These chapters have been selected to combine related areas to aid review and facilitate considered feedback.

Invitation for written submissions

AEMO is committed to continually improve its forecast accuracy to better meet stakeholder needs. AEMO respects the expertise of its stakeholders and values all feedback, which is critical in guiding meaningful progress and developing a strategic vision for the future development of Australia's energy system. This is also consistent with the principles outlines in the National Electricity Rules (NER clause 4A.B.5) and expanded on in the Australian Energy Regulator's Interim Forecasting Best Practice Guidelines published on 20 September 2019.

Stakeholders are invited to submit written responses to the questions outlined in this Consultation Paper, and on other issues related to the inputs and assumptions used in AEMO's NEM forecasting and planning publications. AEMO welcomes any feedback stakeholders are in a position to provide. Submissions need not address every question posed, and are not limited to the specific consultation questions contained in each chapter.

Submissions are requested by Friday 7 February 2020. Submissions should be sent by email to forecasting.planning@aemo.com.au. Where possible, please provide evidence to support your view(s).

In addition, AEMO and CSIRO will hold a joint webinar on 31 January 2020 to discuss the GenCost 2019-20 Draft Report.

Contents

1. Introduction

AEMO provides forecasting and planning information for the National Electricity Market (NEM) as part of its functions under the National Electricity Law and the National Electricity Rules. Primary annual publications include:

- Electricity Statement of Opportunities (ESOO) – provides a 10-year supply adequacy assessment of the NEM, with market and technical data to assess the reliability of the electricity market, and incorporates an independent 20-year forecast for annual consumption and maximum and minimum demand. The ESOO is a key contributor to the assessment of whether the Retailer Reliability Obligations (RRO) will be triggered.

- Integrated System Plan (ISP)[1] – identifies a whole of system plan over a 20-year outlook period to reliably and securely supply customers, while minimising the overall cost of the NEM. The ISP will become the primary means for the identification of energy projects that achieve power system needs in the long-term interests of customers. It is to be made actionable through the conclusion of the Actionable ISP framework. The inputs and assumptions used by AEMO as part of this ISP process, will, when the ISP framework is commenced, also be used by TNSPs in any RIT-Ts to be undertaken on ISP actionable projects.

AEMO is committed to continually improve its forecast accuracy to better meet stakeholder needs. AEMO respects the expertise of its stakeholders and values all feedback, which is critical in guiding meaningful progress and developing a strategic vision for the future development of Australia's energy system.

AEMO's forecasts are guided by AER's Interim Forecasting Best Practice Guidelines (FBPG) published on 20 September 2019. These FBPG clarify how AEMO applies the principles set out in the rules (NER clause 4A.B.5):

- Accuracy: Forecasts should be as accurate as possible, based on comprehensive information and prepared in an unbiased manner. and prepared in an unbiased manner.

- Transparency: The basic inputs, assumptions and methodology that underpin forecasts should be disclosed. should be disclosed.

- Effective Engagement: Stakeholders should have as much opportunity to engage as is practicable, through effective consultation and access to documents and information.

AEMO's Interim Reliability Forecasting Guidelines (currently under consultation) outline how AEMO will follow the FBPG in meeting these principles.

As outlined in these Guidelines, AEMO will consult on inputs and assumptions used in its forecasts each year. Due to the dependencies between various key input components, and the time required to undertake meaningful consultation, it is not practical to wait until all inputs have been finalised before commencing consultation. For example, development of input assumptions related to distributed energy resource (DER) uptake or energy efficiency (EE) are dependent on macro-economic assumptions and price forecasts, so need to be developed after these forecasts are finalised. Providing sufficient time for all inputs to be developed before consulting on them formally would lead to data latency issues. To provide accurate forecasts, AEMO seeks to use the most recent inputs available.

Therefore, a compromise is essential, whereby the annual consultation provides stakeholders with opportunity to provide feedback on the inputs used to develop the most recent forecasts, to help inform improvements to be made for subsequent forecasts. In this way, a continuous cycle of improvements, forecasts and feedback is established, as indicated in Figure 1 below.

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[1] For National Electricity Rules purposes, the ISP will largely incorporate the information required to be contained in the National Transmission Network Development Plan (NTNDP).

Figure 1   Engagement cycle
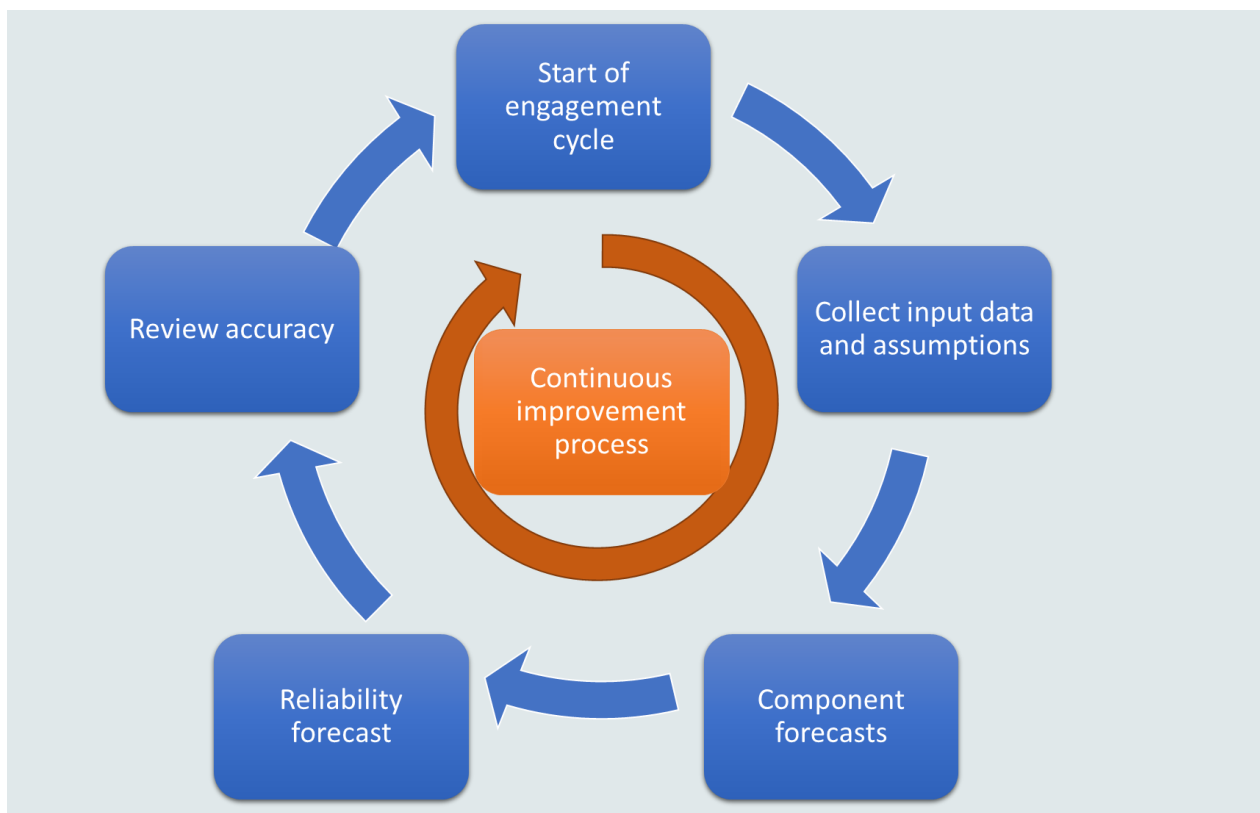
AEMO has prepared this document to provide information and seek stakeholder submissions on inputs and assumptions for AEMO's 2020 forecasting and planning publications. AEMO is specifically seeking feedback on:

- Changes required to key inputs and assumptions used in AEMO's 2019 NEM planning and forecasting publications that affect AEMO's supply and demand forecasting models,
- Appropriateness of new inputs already developed for next year's forecasts, specifically:
  - CSIRO's latest GenCost 2019-20 draft which provides an annual update to generation technology costs, and includes input from Aurecon on current costs for select technologies.
  - Gas prices forecasts, as provided by Core Energy.

Scenarios in 2020

In 2019, in preparation for its ISP, AEMO consulted extensively with stakeholders to develop scenario narratives that are representative of the range of plausible futures of relevance to the NEM. AEMO proposes to continue using these same scenarios in 2020, but update key inputs with latest information that remains consistent with the scenario narrative.

Key inputs and assumptions

This Consultation Paper outlines key inputs required to conduct forecasting of supply and demand affecting the ESOO and ISP within the framework of the RRO and Actionable ISP.

All inputs and assumptions used in applying the forecasting methodologies are generally sourced in one of three ways:

- Directly from participants and key stakeholders via surveys.
- Through research and analysis conducted internally by AEMO.

- Through engagement of expert consultants.

To enable constructive stakeholder feedback as part of the continuous improvement process, it is critical that AEMO be as transparent as possible around its inputs, assumptions and methodologies used. To this end, AEMO published its Forecasting and Planning Scenarios, Inputs and Assumptions Report and accompanying workbook in August 2019[2]. Inputs and assumptions that drive the development of demand forecasts were not thoroughly covered in that report. Much of this information is contained in supplementary materials provided by consultants engaged in the forecasting process as summarised in Table 1 below. Where necessary, further information omissions are outlined in this current consultation for increased transparency.

In addition to this formal consultation, as the inputs for 2020 forecasting and planning purposes are progressively developed, AEMO will seek to validate these inputs through consultation in its Forecasting Reference Group[3].

Table 1   2019-20 supporting forecasting materials

Supporting report	Affecting	Source Location
CSIRO, GenCost 2019-20: Preliminary results for stakeholder review (NEW)	Supply Modelling – hydro availability forecasts	CSIRO GenCost 2019-20 Report
Aurecon, 2019 Costs and Technical Parameter Review (NEW)	Supply Modelling – hydro availability forecasts	Aurecon Report Aurecon Databook
CORE Energy, 2019-20 Wholesale Gas Price Outlook (NEW)	Supply Modelling and Gas forecasting	CORE Energy Report CORE Energy Databook
Deloitte Access Economics, 2019 Long Term economic scenario forecasts	Demand Forecasting – annual consumption and Max/Min Demand	Deloitte Report
CSIRO, 2019 Projections for Small Scale Embedded Technologies Report	Demand Forecasting – annual consumption and Max/Min Demand	CSIRO DER Report
Energeia, Distributed Energy Resources and Electric Vehicle Forecasts Report	Demand Forecasting – annual consumption and Max/Min Demand	Energeia DER Report
Strategy Policy Research, 2019 Energy Efficiency Forecasts	Demand Forecasting – annual consumption (energy efficiency and fuel switching)	SPR Report
Wood Mackenzie, 2019 Coal Cost Projections	Supply Modelling – fuel cost forecasts	Wood Mackenzie Report
Entura, 2018 Pumped Hydro Cost Modelling	Supply Modelling – hydro availability forecasts	Entura Report
AEMO, 2019 Inputs and Assumptions Workbook	Key assumptions used by AEMO in the 2020 Draft ISP	2019 Input and Assumptions Workbook

AEMO's forecasting methodologies

AEMO publishes various forecasting methodologies to increase understanding and improve transparency on forecasting techniques and inputs affecting its electricity (and gas) supply and demand forecasts. These methodologies are available at https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Inputs-Assumptions-and-Methodologies, and include:

- Electricity Demand Forecasting Methodology

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[2] AEMO, 2019 Inputs and Assumptions Workbook, available at: https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Inputs-Assumptions-and-Methodologies. The current version of the 2019 Input and Assumptions Workbook is dated December 2019.

[3] https://www.aemo.com.au/Stakeholder-Consultation/Industry-forums-and-working-groups/Other-meetings/Forecasting-Reference-Group

- Market Modelling Methodology
- Reliability Standard Implementation Guidelines
- Energy Adequacy Assessment Projection Guidelines
- Reliability Forecasting Methodology (being replaced by the Interim Reliability Forecast Guidelines)
- ESOO Methodology

AEMO also identifies annual improvements that may be applied to its forecasting approach, published as part of the Forecasting Accuracy Report.

These forecasting methodologies, and the improvement programme, will be consulted on separately. This current consultation focuses on the inputs and assumptions to be used in applying the methodologies outlined in these documents to develop forecasts in 2020.

1.1   Consultation details

Questions on which AEMO seeks feedback

AEMO seeks feedback from all interested parties on the variations in current inputs and assumptions that should apply in AEMO's 2020 forecasting and planning activities.

Questions are presented in the chapters of this report where AEMO is seeking evidence-based commentary and guidance. These chapters have been selected to combine related areas to aid review and facilitate considered feedback.

Table 2   Summary of chapters for consultation

Chapter	Summary
2. Annual energy consumption	Key inputs: Annual consumption forecasting
3. Maximum and Minimum Demand	Key inputs: Maximum and minimum demand forecasting
4. Supply modelling inputs	Key inputs: Supply modelling, including the GenCost 2019-20 Draft Report
5. Questions	Summary of questions posed across the chapters, to guide (but not limit) stakeholder engagement.

Invitation for written submissions

AEMO values any feedback stakeholders are in a position to provide, and welcomes written submissions on any inputs or assumptions outlined in this report or in supplementary material that supports this Consultation. Submissions need not address every question posed, and are not limited to the specific consultation questions contained in each chapter.

Stakeholders are invited to submit written responses to the questions outlined in this paper, and on other issues related to the inputs and assumptions used in AEMO's NEM forecasting and planning publications.

Submissions are requested by Friday 7 February 2020. Submissions should be sent by email to forecasting.planning@aemo.com.au. Where possible, please provide evidence to support your view(s).

In addition, AEMO and CSIRO will hold a joint workshop on 31 January 2020 to discuss the GenCost 2019-20 Draft Report.

The final inputs and assumptions report will be published no later than July 2020, after all information has been refreshed for use in AEMO's ESOO.

1.2 Other consultations running in parallel

Concurrently, AEMO is consulting on a number of other forecasting and planning aspects (see Table 3) including its Draft Integrated System Plan (ISP) for 2020. Generally, inputs, scenarios and assumptions should not be re-opened for this consultation for the Draft 2020 ISP. This consultation on inputs and assumptions is for use in other 2020 publications.

Table 3   Concurrent consultations December 2019 to March 2020

Consultation	Who	Description	Open	Close
Draft ISP Rules	Energy Security Board	Converting the ISP into Action - Draft changes to the National Electricity Rules[4] Submissions to: info@esb.org.au	20-Nov-19	17-Jan-20
Draft ISP	AEMO	General comments on the Integrated System Plan for the NEM, draft report, including the proposed optimal development path. Call for submissions located within this Draft ISP document, Part E. Submissions to: isp@aemo.com.au	12-Dec-19	21-Feb-20
QNI Medium & VNI West – call for non-network options	AEMO	Submissions relating to non-network options for the QNI Medium and VNI West actionable ISP projects. Call for submissions located in separate notice published on AEMO website[5] Submissions to: isp@aemo.com.au	12-Dec-19	13-Mar-20
VNI West PSCR	AEMO	Project specification consultation report for the Vic-NSW Interconnector West RIT-T[6] Submissions to: VNIWestRITT@aemo.com.au	12-Dec-19	13-Mar-20
Forecasting and planning Inputs and Assumptions	AEMO	This Consultation: Forecasting and Planning inputs and assumptions for 2020[7] Submissions to: forecasting.planning@aemo.com.au	12-Dec-19	7-Feb-20

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[4] http://www.coagenergycouncil.gov.au/publications/consultation-draft-isp-rules

[5] https://aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Integrated-System-Plan/2019-Integrated-System-Plan

[6] https://aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Victorian-transmission-network-service-provider-role/VNI-West-RIT-T

[7] https://aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Inputs-Assumptions-and-Methodologies

2. Annual energy consumption

Assumptions used in forecasting energy consumption are contained in this report, in expert Consultant reports identified in the Supplementary Materials (listed in Table 1), in the Electricity Demand Forecasting Methodology Information Paper, and in the 2019 ESOO.

AEMO is seeking feedback on the following questions:

- Are the assumptions contained within this report or the Consultant reports reasonable - Deloitte, Strategy Policy Research, and DER Consultants, CSIRO and Energeia? What alternatives (with evidence) could provide an improvement to the current assumptions?

AEMO applies a component-based forecasting approach to model forecast annual electricity consumption. This chapter provides additional transparency regarding key inputs impacting the forecasting of each core component.

The forecasting methodology used in forecasting annual consumption used in AEMO's forecasting and planning publications can be found in the Electricity Demand Forecasting Methodology Information Paper. Assumptions that have been used in applying the methodology in the latest publications are outlined in this document, with rationale and references where possible. In addition, the chapter outlines supporting materials that may provide additional clarity on assumptions of various components.

Additional information describing key inputs and outputs of the 2019 ESOO forecasts are described in the 2019 ESOO publication, and can be found under 2019 NEM ESOO Supporting Material on the NEM ESOO website.

AEMO's separation of residential and business distribution connected consumption from the aggregate electricity meter data is informed by distribution data collated by the AER, as outlined in Appendix A7 from the Demand Forecasting Methodology. AEMO has used this data to derive annual consumption targets to calibrate to when performing half-hourly splits between residential and business sector. The configuration and execution of the separate business and residential forecast models - with their different demand drivers – will determine the total for the business and residential components for each subsequent period in the forecast.

AEMO also receives stated transmission and distribution losses (as a percentage) from the AER for each network business (refer to section 4.2 of the Demand Forecasting Methodology Paper for details). AEMO carries over the latest reported loss factor in the forecast horizon.

2.1 Residential forecasts

The main drivers of AEMO's residential sector forecast model include the number of new connections, DER trends (including rooftop PV, batteries, and EVs), appliance uptake and usage, energy efficiency (EE) impacts, climate change, price, fuel switching and consumer behavioural response.

- Energy Efficiency (EE): The Commonwealth and state governments have developed measures to mandate or promote EE uptake across the economy, and AEMO has considered the impact of these measures on forecast residential consumption.

- Fuel Switching (FS): AEMO has incorporated fuel-switching in the EE forecasts and Appliance Index for 2019.
- Distributed Energy Resources (DER): AEMO's forecasts account for forecast growth in DER. See Section Error! Reference source not found. for further details.

2.1.1 Energy Efficiency and Fuel Switching

AEMO provides descriptions of its 2019 energy efficiency methodologies in AEMO's Electricity Demand Forecasting Methodology Information Paper. Further information regarding the 2019 Energy Efficiency forecasts is also provided in the 2019 ESOO.

To forecast the projected levels of energy efficiency, AEMO engaged an independent consultant, Strategy Policy Research (SPR), to conduct a review and forecast of energy efficiency opportunities and emerging policies. SPR provided an overview of the various components impacting energy efficiency trends, and key assumptions applied in producing this forecast. SPR apportioned energy savings by load segment using ratios developed by AEMO for each NEM region, considering the total annual consumption that is sensitive to cool weather (heating load) and to hot weather (cooling load). The residual consumption is considered temperature-insensitive and is apportioned to baseload.

In 2019 the fuel switching between gas and electricity for space and water heating is embedded in the EE forecasts and detailed in the consultant's report.

AEMO adjusted the consultant's residential forecasts and applied a discount factor of around 25%, similar to the small-to-medium enterprises (SME) forecast (as detailed in the Business Forecasts section in Section 2.2).

2.1.2 Residential usage per connection

Daily average consumption per connection was determined by:

- Estimating the regional underlying consumption by adding the expected electricity generation from rooftop PV. Adjustments are applied to include avoided transmission and distribution network losses from residential consumers with rooftop PV generation.
- Calculating the daily average underlying consumption in each region.
- Estimating the daily underlying consumption per residential connection by dividing by the forecast number of connections. A daily regression model is used to calculate the daily average consumption split between baseload, cooling and heating load.

For the 2019 forecasts, AEMO updated its connections forecasts by applying the Housing Industry Association (HIA) dwelling forecasts, and both the Australian Bureau of Statistics (ABS) 2018 long-term population projections and the ABS 2019 household dwelling projections. In the first four years, the new connections forecast uses the HIA dwelling completion forecasts. Beyond four years, AEMO applies ABS housing and population forecasts. AEMO is seeking to determine whether trend analysis of meter count data may be applied in the near term, in place of or in companion with the HIA forecasts, to validate that projection before gliding into the ABS housing projections.

The table below outlines the average annual consumption by household, weather-normalised, calculated for the 2019 ESOO forecasts.

Table 4   Average residential load outputs

Component	Detail / Impact	QLD	NSW	VIC	SA	TAS
Base load	MWh per year that is assumed for a 50th percentile weather year	5.66	5	4.13	4.5	6.16
Temperature sensitive cooling load	MWh per year that is assumed for a 50th percentile weather year	0.9	0.43	0.33	0.43	0
Temperature sensitive heating load	MWh per year that is assumed for a 50th percentile weather year	0.18	0.9	0.58	0.88	2.49

2.2   Business forecasts

The business sector captures all non-residential consumers of electricity in the NEM. These have been segmented into two broad categories, Large Industrial Loads (LILs) and small to medium enterprises (SME). The sector is split in this way to better capture the different drivers affecting forecasts for these major consumer categories.

2.2.1   Large industrial loads

AEMO annually interrogates meter data to identify larger energy-intensive consumers, likely to be industrials. These are identified by applying a consumption threshold - demand must be observed to be greater than 10 MW for greater than 10% of the latest financial year.

Large industrial loads (LILs) are interviewed and surveyed, providing AEMO with direct information for use in the long-term forecasts. Details of the approach can be found in section 2.2 of the Electricity Demand Forecasting Methodology.

In AEMO's 2019 ESOO forecast, and in accordance with the forecasting scenario definitions, AEMO provided greater consideration of climate impacts on the use of desalination facilities. While near term consumption patterns reflect announced water supply contracts, AEMO applies adjustments to the survey information regarding the long term energy usage provided by desalination plants to reflect AEMO's assumptions regarding climate impacts affecting rainfall projections, as noted in AEMO's August 2019 Forecasting and Planning Scenarios, Inputs and Assumptions Report. This adjustment is applied to increase consistency with the assumed climate impacts of each forecast scenario. This adjustment is described in the following table.

In applying the stated adjustment, AEMO has applied an estimated energy consumption rate of approximately 3.7 GWh/GL.

Table 5   Adjustment assumptions for desalination LILs[8],

Scenario	Inflow reduction by 2040	VIC	SA
All	N/A	Desalination Plant Short Term Consumption based on latest water supply contracts.	Desalination Plant Short Term Consumption based on latest water supply contracts.
Slow Change	13.7% reduction	7.56 GWh/annum	5.09
Central	10.2% reduction	5.14 GWh/annum	3.46
Step Change	2.9% reduction	5.14 GWh/annum	2.82

2.2.2   Small-to-medium enterprises

The core drivers affecting the business forecasts are economic growth, energy efficiency, price and climate change impacts.

Economic forecasts

After removing the large industrial loads from business sector consumption, AEMO applies the consumption trends influenced by broader economic activity. Economic activity is measured by forecasting the trends in regional Gross State Product (GSP) and household disposable income.

To isolate the SME loads, AEMO:

- accounts for the forecast energy associated with LIL's, who may have bespoke influences affecting their forecast consumption trends that may not be correlated to regional economic activity
- adjusts for known structural effects within historical time series, such as the decline of heavy industries or specific boom sectors (such as the LNG or large closures)
- adjusts the impact of large segments with growth potential for energy usage but not directly affected by economic forces (e.g. desalination facilities).

The aggregate of this segment is categorised as SME and represents the sector to which the economic models are applied. In all regions (excluding Tasmania) a 5-10 year historical dataset is used. The data is further truncated to remove structural effects still present in the data series (e.g. Global Financial Crisis and sectoral changes). Energy usage and GSP are correlated. Regression analysis produces a central estimate for recent consumption (5-10 year history) and economic activity for the starting point of the model.

The derived GSP coefficient may be adjusted over the 20-year horizon to reflect the assumption of increasing in natural energy productivity[9] or where a recent boom is clear in the data set (e.g. QLD mining boom).

In the case of Tasmania, the SME segment is a much smaller relative share of total consumption and consists of numerous small businesses. The LIL sector accounts for more than 75% of the business sector forecast; AEMO's methodology means that much of the business sector growth is influenced by consumer survey responses. Given this low proportion, there is limited correlation between GSP (driven by significant industrial activity) and SME energy usage, and so AEMO's methodology in Tasmania applies population trends to

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[8] AEMO adjusts the volume of energy required to service known water supply contracts, increasing these proportionally by the water inflow reductions defined in AEMO's 2019 Input and Assumptions Workbook. This effectively increases the use of desalination to balance the reduction in natural inflows.

[9] https://www.mckinsey.com/industries/electric-power-and-natural-gas/our-insights/the-decoupling-of-gdp-and-energy-growth-a-ceo-guide, accessed 10th December 2019

provide a current estimate of per capita consumption, using ABS population forecasts to scale the forecast forward.

A limitation of using macro trends is that structural effects in the economy that potentially give rise to future GSP/MWh ratio changes are not explicitly captured. This is addressed in the SME and LIL models with external forecasts for DER (EVs, PV, batteries) and energy efficiency forecasts that include consideration of potential changes to federal and state policies, such as the National Construction Code, that may impact on building stock[10]. AEMO monitors individual consumer sectors (e.g. data centres) where sufficient data is available.

Currently AEMO is seeking economic advice at the ANZSIC[11] division level to allow greater business sector segmentation.

Energy Efficiency

AEMO develops forecasts of energy efficiency as a means of adjusting the energy consumption trend from the economic indicators to reflect expected improvements in the long term, influenced by various technological and policy-driven change. The methodology and assumptions were developed in 2019 in consultation with AEMO's energy efficiency consultants – Strategy Policy Research. The key details of this component forecast are published in the SPR report, including the influence of existing and proposed national and state energy policies, as well as observed energy savings from existing and historical measures.

As stated in the Electricity Demand Forecasting Methodology Information Paper on page 16-17 AEMO adjusted the forecasts to fit with the SME model by:

- Removing savings from Commercial and Industrial LILs,

- Rebasing the consultant's forecast to the SME model's base year,

- Removing the estimated future savings from activities that took place prior to the base year,

- Extending the savings attributed to state schemes beyond legislated end dates, on the assumption that a significant percentage (75%) of activities would continue as business as usual, and

- Revising the consultant's emissions target for the Victorian Energy Upgrades Program, of 6.5 million tonnes of CO_2-e beyond 2020, to a more conservative target reduction of 10% pa from 2021 until the Program is legislated to end in 2030.

AEMO applied a discount factor of approximately 25% to the adjusted energy efficiency forecasts, to reflect the potential increase in consumption that may result from lower electricity bills. The discount factor also reduces the risk of overestimating savings from potential double-counting and non-realisation of expected savings from policy measures. This adjustment is in addition to steps already taken by the consultant to account for the so-called rebound effect, For more details on assumptions, trends and drivers on energy efficiency see the energy efficiency report produced by *Strategy. Policy. Research. Pty Ltd*.

Price elasticity of demand

Energy consumption is reduced in response to rising prices, although there may be some lag in this response. Price elasticity of demand assumptions are relatively low compared with previous estimates[12], recognising that recent sustained price rises, and anticipated continued price rises, have strongly influenced consumer behaviours and purchasing decisions, and future price impacts may have a lessening impact.

The magnitude of price increases also means theoretical price impacts can extend into loads that are less vulnerable to price, and therefore that have an assumed smaller price elasticity of demand sensitivity. Ideally, consumers with differing levels of sensitivity to price are treated separately, but the data availability and

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[10] Building stock refers to the class of buildings and businesses that are present in the economy. The energy footprint of buildings – measured by using an energy rating system - will change over time as the stock of building types evolves – either through appliance shifts within a business or through construction / design improvements to the building itself.

[11] ANZSIC refers to Australian and New Zealand Standard Industrial Classification, which provides a method for disaggregating and reporting economic statistics for individual industries.

[12] Studies in 2002 (NIEIR), 2010 (Monash) and 2016 (Ausgrid) suggest price elasticity ranges of -0.1 to -0.4.

therefore forecasting sophistication does not allow for this treatment currently. This further supports the justification for using a relatively low-price elasticity of demand assumption.

Coefficients for price elasticity for SME consumers were benchmarked against a broad literature review by AEMO (refer to Appendix A9 of the 2018 Electricity Demand Forecasting Methodology Paper).

Table 6   Price elasticity assumptions

Region	Scenario		Value	Detail / Impact
All regions	Central	Price Co-efficient	-10.0%	Proportion of energy consumption that is subject to the price elasticity of demand for a 1% increase in price
All regions	Step Change	Price Co-efficient	-5.0%	Proportion of energy consumption that is subject to the price elasticity of demand for a 1% increase in price
All regions	Slow Change	Price Co-efficient	-15.0%	Proportion of energy consumption that is subject to the price elasticity of demand for a 1% increase in price

AEMO is seeking feedback on the following questions:

- Are these price elasticities reasonable for electricity consumption for the scenarios defined?
- Are other factors appropriate to consider for the business segment?
- How can sustained high prices impact on energy consumption in the long term, and captured in forecasts?

2.3   Climate change impact

AEMO's consumption forecasts assume the application of Representative Concentration Pathways (RCPs) per scenario. Each scenario has been allocated an RCP that represents the global greenhouse gas concentration trajectory. The RCPs provide a common benchmark used globally to describe possible pathways for atmospheric greenhouse gas concentrations, and the associated climate change impacts. These have been defined as part of AEMO's inputs, scenarios and assumptions consultation in February – July 2019.

In the 2019 ESOO, a bottom-up climate change impact was calculated for each RCP scenario. Using the same percentage increase/decrease in cooling/heating load from the 2018 ESOO, these percentages were used as a climate change index to adjust up/down the 2019 cooling/heating load accordingly. However, the net effect is mathematically equivalent to reducing the HDDs/CDDs as described in section A.2.3 in the Electricity Demand Forecasting Methodology Paper.

For the 2020 forecasts AEMO proposes to continue to apply the climate predictions on a scenario basis, using the same approach outlined in the . The applied assumptions are outlined in the table below.

The impact of these RCPs influences the longer term more-so than the medium term, given that the temperature rise is similar between scenarios due to locked in historical emissions, and the lag that climate action is expected to have on addressing global temperature rise.

Table 7   Climate adjustment factors per scenario

Scenario	RCP scenario	Rainfall / hydro inflow reduction by 2040 *Presented as Mainland (Tasmania)*	Detail / Impact
Central / High DER	7.0	-10% (-6%)	Approximately 0.5 degree rise to 2040, affecting CDD (lower) and HDD (higher). This impact is applied consistently across all scenarios to 2045, as temperature dispersion is minimal to this time. After 2045 AEMO applies temperature dispersion across scenarios.
Slow Change	8.5	-13% (-7%)	
Fast Change	4.5	-5% (-4%)	
Step Change	1.9 or 2.6	-3% (-2%)	

Table 8   Impact of changing temperatures

Scenario	Description	QLD	NSW	VIC	SA	TAS
All[13]	Average annual increase in expected CDDs	0.57%	0.80%	0.72%	1.70%	0.72%
	Average annual decrease in expected HDDs	-0.54%	-0.71%	-0.63%	-0.54%	-0.63%

2.4   Distributed Energy Resources (DER)

Distributed Energy Resources include small-scale photovoltaics (PV) installations, battery storage systems and electric vehicles.

2.4.1   Small-scale PV forecast:

Uptake trends:

Small-scale PV systems affect both annual consumption and maximum and minimum demand forecasts, and consists of a range of different installation types.

- Rooftop PV captures residential and commercial systems:
  - Systems that have a nominal rated power output of up to 10kW are labelled residential.
  - Systems larger than 10 kW and less than 100 kW are labelled commercial.
- PV non-scheduled generators (PVNSG) refers to systems larger than 100 kW and smaller than 30 MW (the threshold for semi-scheduled status).
  - To accommodate different drivers of some installations the PVNSG category is split into systems sized 100 kW to 1 MW, 1 MW to 10 MW and 10 MW to 30 MW.
  - The PVNSG group excludes utility-scale systems (>30 MW) that are semi-scheduled and included in the operational demand definition.

Drivers affecting the uptake trajectories for each of these classifications are provided by AEMO's DER consultants. In 2019 AEMO engaged CSIRO and Energeia to provide these uptake trajectories. The models developed and applied by each Consultant are different, giving AEMO a broader spectrum of expected DER developments to consider across the forecast scenarios. AEMO applied the following Consultant forecasts to the scenarios:

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[13] AEMO applies climate adjustment factors in accordance with the RCP for each scenario. The adjustment factor is equal for RCP scenarios of RCP4.5 or lower. A larger variance is applied in RCP scenarios higher than RCP4.5. The deviation of higher RCP scenarios relative to the RCP4.5 trajectory occurs after 2045.

Table 9   Consultant DER forecast to Scenario mapping

	Slow Change	Central	Fast Change	High DER	Step Change
Consultant's scenario name	CSIRO Slow Change	CSIRO Neutral	CSIRO Fast Change transitioning to CSIRO Neutral growth beyond 2025	Energeia Neutral 45%	CSIRO High DER

The uptake forecasts represent effective capacity, designed to capture degradation of panel performance due to age. The rate of degradation is set by the forecast providers. See references in Section 5 to the consultants (CSIRO and Energeia) reports.

- CSIRO DER Report
- Energeia DER Report

Degradation is only applied to future years as the nominal generation traces applied to estimate small scale PV and PVNSG generation[14] is calibrated to the current installed capacity and will account for any panel degradation to date. These degradation rates are listed in each Consultant report for reference.

Generation forecasts:

Rooftop PV generation is calculated from nominal generation traces provided by Solcast[15] each consisting of an estimate of the generation in terms of power (MW) as a percentage of installed capacity. This is scaled up to any required effective capacity level. When converted to energy output, in units of kWh, it can then be summed for annual generation or used at half-hourly level in the simulations undertaken to forecast maximum and minimum demand distributions.

AEMO assumes that Rooftop PV developments are installed with a spatial distribution that remains similar to historical developments. In this way, historical geographically-distributed generation estimates are applied to forecast PV generation in future years.

PVNSG generation is calculated from nominal generation traces developed at AEMO using the System Advisor Model[16], and scaled up to the forecast PVNSG capacity. When converted to energy output, in units of kWh, it can then be summed for annual generation or used at half-hourly level in the simulations undertaken to forecast maximum and minimum demand distributions. Similar to rooftop PV, PVNSG spatial distribution is also assumed to remain similar to historical developments, to enable historical generation distributions to be applied to forecast PVNSG generation.

Further assumptions:

- Systems with sizes between 100 kW and 10 MW are assumed to be fixed-flat panel systems.
- Systems between 10 MW and 30 MW are assumed to be single axis tracking systems.

2.4.2   Battery storage forecast

AEMO has considered behind-the-meter residential and commercial battery systems that have the potential to change the future demand profile in the NEM, and thus also maximum and minimum demand.

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[14] This degradation factor applies to small-scale PV only.

[15] See: www.solcast.com.

[16] See https://sam.nrel.gov/

Averaged unaggregated battery traces for NSW are provided in the 2019 Input and Assumptions Workbook. Unaggregated battery profiles are highly dependent on rooftop PV output and household load which both vary with time of year. The contribution of unaggregated batteries (those that are not coordinated as part of a Virtual Power Plant [VPP]) to managing evening grid-level peak demands is expected to be relatively low, as default battery operation targets self-consumption optimisation.

Aggregated batteries operating as part of a VPP have greater potential for full utilization of their peak capacity at peak demand times. Given the controllability of this aggregated battery class, VPPs are modelled as a source of supply within the market simulation software AEMO uses when conducting supply adequacy assessments (i.e. the PLEXOS market simulation software used in the ESOO and ISP, for example). In this way, VPPs are considered as an alternative source of energy supply (similar to grid-scale batteries and pumped storage facilities), rather than an embedded demand reducer.

The figure below demonstrates a typical summer day's operation of unaggregated battery and an associated rooftop PV system for a representative household. The proportion of batteries allocated to VPPs and unaggregated is available in the 2019 Input and Assumptions Workbook, and differ by scenario.

Figure 2   Example average non-aggregated battery daily charge/discharge profile in Summer
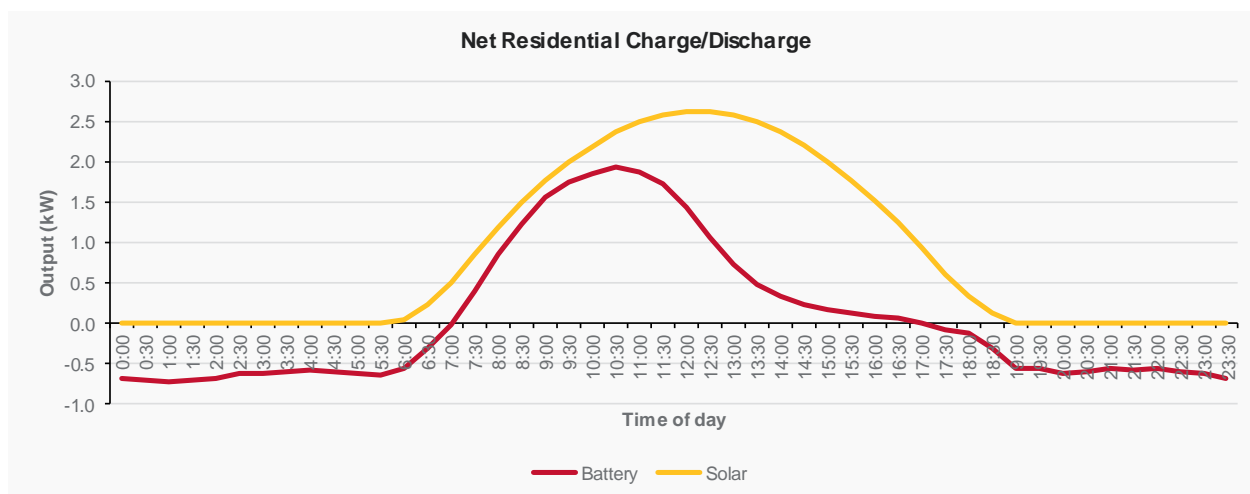
Figure 3   VPP Aggregation trajectory
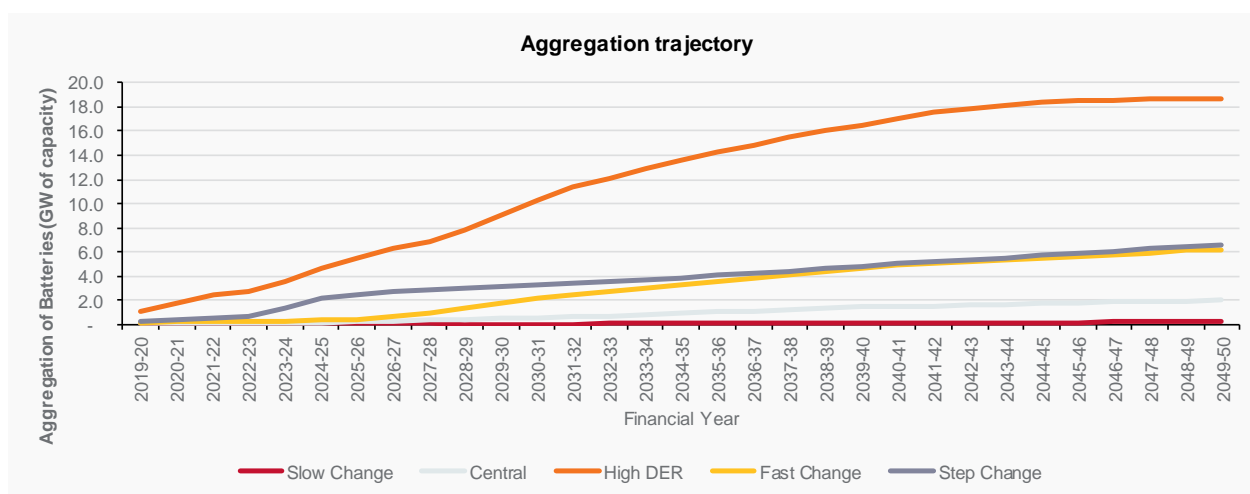
AEMO assumes a standard round-trip efficiency of 85% for customer battery systems. This means that 15% of stored energy is lost either through charging, storing, or discharging.

AEMO has published the half hourly traces for each of the demand components as part of the 2020 ISP Database. Other technical details of battery devices are contained within the Consultant reports.

- CSIRO DER Report

- Energeia DER Report

2.4.3   Electric vehicle forecasts:

AEMO's DER consultancy engagement included forecasting of electric and alternative fuelled vehicles. The forecast for electric vehicle uptake, their annual consumption and charging profiles are all provided by the forecast providers, CSIRO and Energeia.

- CSIRO DER Report

- Energeia DER Report

Forecast uptake, relative size MW capacity vs MWh of storage and the charging/discharging profiles are each described and adopted from each Consultant. Inclusion of vehicle to home vehicle capabilities and hydrogen fuelled vehicles is described in the DER Consultant Reports.

The drivers influencing DER uptake across DER categories are outlined by CSIRO and Energeia and include:

- the charge and discharge profiles assumed by each consultant of batteries and EVs,

- the average system sizes of batteries and PV systems,

- the average travel distances and charging infrastructure affecting EV consumption.

- other influences

Normalised charge profiles for electric vehicles are provided in the 2019 Input and Assumptions Workbook. The details of the methodology used to develop these are provided in each Consultant reports (referenced above).

Feedback received from this consultation on the 2019 assumptions will be provided to the consultants for consideration in preparing the 2020 uptake forecasts and charge profiles.

3. Maximum and Minimum Demand

Assumptions used in forecasting energy consumption are contained in this report, in expert Consultant reports identified in the Supplementary Materials (listed in Table 1), in the Electricity Demand Forecasting Methodology Information Paper, and in the 2019 ESOO.

AEMO is seeking feedback on the following questions:

- Are the assumptions presented in these reports reasonable? If not, what alternatives (with evidence) could provide an improvement to the current values?

AEMO applies a probabilistic approach to forecasting maximum and minimum demand. This chapter provides additional transparency regarding key assumptions made within the maximum/minimum demand forecasting approach and the subsequent development of half-hourly traces matching these targets.

3.1   Maximum/minimum demand forecasts

Maximum demand is determined in a process simulating each half-hour of a year thousands of times with different weather inputs and observing the distributions of the seasonal maximum and minimum demands across the simulation years.

For future years, the process splits demand in each half-hour into heating, cooling and baseload. The process then grows half-hourly heating load, cooling load and baseload components separately by annual or seasonal growth indices such as energy efficiency of air-conditioners decreasing cooling load, or population growth that will increase half-hourly load of all three types: heating, cooling and baseload. As a result, the load factor between maximum demand and annual energy changes over time. The methodology is explained in detail in AEMO's Electricity Demand Forecasting Methodology Information Paper[17].

The following tables outline key assumptions made when forecasting maximum and minimum demand.

Table 10   Large industrial loads contribution to maximum/minimum demand

Region	Scenario	Component	Detail / Impact
All regions (exc. Tasmania)	All	Large Industrial Loads	Assumed to contribute to maximum/minimum demand with its average capacity factor.
Tasmania	All	Large Industrial Loads	Assumed to contribute to maximum/minimum demand with its average historical contribution to each of the three previous years' top 10 half-hours of the top days for maximum and minimum demand respectively for the relevant season.

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[17] See: https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/NEM_ESOO/2019/Electricity-Demand-Forecasting-Methodology-Information-Paper.pdf.

Table 11   Other non-scheduled generation contribution to maximum/minimum demand

Region	Scenario	Component	Detail / Impact
All regions	All	Other non-scheduled generation	Assumed to contribute to maximum/minimum demand with its average historical capacity factor to each of the previous three years' top 10 half-hours for maximum and minimum demand respectively for the relevant season.

Table 12   Network losses at time of maximum/minimum demand

Region	Scenario	Component	Value	Detail / Impact
NSW	All	Distribution losses	4.63120%	Based on published historical losses by AER.
QLD	All	Distribution losses	4.80370%	Based on published historical losses by AER.
SA	All	Distribution losses	6.57434%	Based on published historical losses by AER.
TAS	All	Distribution losses	5.31000%	Based on published historical losses by AER.
VIC	All	Distribution losses	5.12119%	Based on published historical losses by AER.
NSW	All	Transmission losses	2.29000%	Estimated by AEMO.
QLD	All	Transmission losses	2.57800%	Based on published historical losses by AER.
SA	All	Transmission losses	2.61821%	Based on published historical losses by AER.
TAS	All	Transmission losses	2.43000%	Based on published historical losses by AER.
VIC	All	Transmission losses	2.61658%	Based on published historical losses by AER.

Table 13   Auxiliary load at time of max/min demand

Region	Scenario	Component	Detail / Impact
All regions	All	Other non-scheduled generation	Assumed to contribute to maximum/minimum demand with its average modelled contribution (across all PLEXOS simulations) to the top 10 half-hours for maximum and minimum demand respectively for the relevant season.

AEMO generally uses its latest relevant PLEXOS modelling outcomes to get the modelled contribution of auxiliary load at time of maximum/minimum demand. This is based on modelled generator dispatch with each generator having auxiliary load factors as published in AEMO's 2019 Input and Assumptions Workbook.

3.1.1   Saturation of energy efficiency impacts during high temperatures

Any general saturation of demand during extreme temperatures is captured directly in the maximum/minimum demand model which, through its data-driven approach, formulates a non-linear relationship between temperature and demand. Whether such behaviour exists depends on day types, time of day and region.

In addition to this, and driven by assumptions, is the saturation of certain energy efficiency impacts during high-temperature high-demand events. For example, a house with a 4-star energy efficiency rating may remove (or significantly lower) the need for cooling at moderate temperatures over a 2-star rated house, but the air conditioners may still have to run at full during extreme temperature events.

The model recognises the saturation of energy efficiency by calculating the cooling load growth index with a proportion of energy efficiency removed such that it is no longer offsetting cooling load consumption in the future. The proportion of energy efficiency removed (or level of saturation) starts at zero in the base year (as the model is based on the current system, including any energy efficiency measures) and scales up each year for the life of the forecast. As result, for example only 90% of the forecast energy efficiency measures may be used for extreme high temperature days in a future year, representing a 10% saturation.

The scaling was informed by the residential housing stock cooling model provided to AEMO as part of the 2019 Energy Efficiency consultancy (see Section 5 for link to the study). With this model, AEMO calculated the saturation of the impacts of different star rated buildings on extreme temperature days versus typical summer days and projected the impacts forward based on the forecast ratio of buildings with each star rating.

During high temperature events, defined by the trigger in the table below, the cooling load index with saturated energy efficiency is used rather than the cooling load with the full energy efficiency impact passed through.

Table 14   Energy efficiency saturation settings

Region	Scenario	Component	Value	Detail / Impact
All regions	All	Temperature for selecting if energy efficiency saturation index should be applied	35 degrees	Temperature in degrees Celsius which if exceeded triggered the saturated growth index rather than the unsaturated growth index to be used.

The current trigger temperature is informed by the temperatures modelled in AEMO's analysis of the energy efficiency saturation. AEMO may revise this in the future as more data becomes available.

3.2   Half-hourly demand trace scaling

Demand traces (referred to as demand time-series in general terms) were prepared by deriving a trace from a historical reference year (financial-year) and growing (scaling) it to meet specified future characteristics using a constrained optimization function to minimize the differences in shape between the grown trace and the targets.

The traces are prepared on a financial year basis, to match various forecast targets, categorised as:

- Maximum summer demand (at a specified probability of exceedance level).
- Maximum winter demand (at a specified probability of exceedance level).
- Minimum demand (at a specified probability of exceedance level).
- Annual energy consumption.

The methodology is explained in detail in AEMO's Electricity Demand Forecasting Methodology Information Paper[18]. The following tables outline additional assumptions used in the process.

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[18] See: https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/NEM_ESOO/2019/Electricity-Demand-Forecasting-Methodology-Information-Paper.pdf.

Table 15   Summer season definitions when scaling to maximum demand

Region	Scenario	Component	Detail / Impact
All regions (exc. TAS)	All	Summer maximum demand target	Months from December to March grown to the specified target level each financial year.
Tasmania	All	Summer maximum demand target	Months from December to February grown to the specified target level each financial year.

Table 16   Number of periods scaled to maximum/minimum targets

Region	Scenario	Component	Value	Detail / Impact
All regions	All	Maximum demand targets (summer or winter) – 10% POE	4 days"	Process starts with scaling the highest 4 days in the relevant season as per methodology. If the resulting trace does not match the target, it will increase it in increments of 5 until the created trace matches the target value.
All regions	All	Maximum demand targets (summer or winter) – 50% and 90% POE	4 days"	Process starts with scaling the highest 11 days in the relevant season as per methodology. If the resulting trace does not match the target, it will increase it in increments of 5 till the created trace matches the target value.
All regions	All	Minimum demand target (annual)	N/A	Process starts with scaling the lowest 40 half-hours as per methodology. If the resulting trace doesn't match the target, it will increase it in increments of 150 till the created trace matches the target value.

4. Supply Modelling inputs

Assumptions used in forecasting the NEM energy supply mix are contained in this report, in expert Consultant reports identified in the Supplementary Materials (listed in Table 1), in the 2019 Input and Assumptions Workbook, and in the 2019 ESOO.

AEMO is seeking feedback on the following questions:

- Are the inputs and assumptions presented in these reports reasonable? If not, what alternatives (with evidence) could provide an improvement to the current values?

Additionally, AEMO and CSIRO have specific questions related to the GenCost report:

- Do the new global electricity scenarios outlined in the GenCost 2019-20 Draft Report explore the plausible range of outcomes with regard to technological change of known technologies?
- Are the updated current capital cost assumptions reflective of current project costs?
- Are the inputs and assumptions for the capital cost projection model reasonable?
- Are the inputs and assumptions for the levelized cost of electricity calculations reasonable?

4.1   Generation technology costs

GenCost is a collaboration between CSIRO and AEMO, together with stakeholder input, to deliver an annual process of updating electricity generation and storage costs. This information is used by AEMO and industry to assist in forecasting and planning.

As part of this Consultation, AEMO is seeking stakeholder engagement on the draft cost and technical projections within the CSIRO GenCost 2019-20 Draft Report. This GenCost 2019-20 Draft Report incorporates updated cost and performance data for new generation technologies, based on information provided by Aurecon. It also includes a wider range of potential capital cost reduction paths for wind and solar PV based on feedback received around appropriate global electricity generation scenarios that now more consistently align with AEMO's scenario narratives.

AEMO and CSIRO have engaged broadly with industry stakeholders throughout the GenCost 2019-20 project to validate preliminary estimates of future generation costs and other resource parameters and develop the global scenarios. To do this, AEMO and CSIRO have conducted webinars or in-person workshops to review preliminary outcomes.

A further webinar is planned for 31 January 2020 to give stakeholders an opportunity to ask clarifying questions prior to providing written submissions to this Consultation.

4.1.1   Aurecon draft report – current costs

As part of the GenCost project, Aurecon were engaged by AEMO to prepare a concise new entrant generation and storage technical parameter report based on current costs. This report considers the technical and financial parameters for a selection of development technologies as determined by broad stakeholder consultation.

The report prepared by Aurecon is to be considered as a supplementary update to the GHD 2018 AEMO Cost and Technical parameter review[19] focusing on maturing technologies whose costs are most likely to have changed in the past year.

The following technologies of key focus in the Aurecon report as determined by stakeholder consultation are:

- Onshore wind,
- Offshore wind,
- Large-scale solar PV,
- Solar thermal (with and without storage),
- Reciprocating engines,
- Combined-cycle gas turbine (CCGT),
- Open-cycle gas turbine (OCGT),
- Electrolysers / fuel cells, and
- Battery Energy Storage Systems (BESSs) with 1 to 8 hours storage.
- The following parameters are presented in detail in the accompanying Aurecon report and data package:
- Performance – such as output, efficiencies, and capacity factors,
- Timeframes – such as for development and operational life,
- Technical and operational parameters – such as configuration, ramp rates, and minimum generation, and
- Costs – including for development, capital costs and O&M costs (both fixed and variable).

This package of work, produced in collaboration with industry and working groups, formed a key input to the long-term capital cost curves in CSIRO's GenCost 2019-20 Draft Report.

4.1.2   GenCost 2019-20 draft forecasts

As part of this consultation, AEMO is seeking feedback on the new technology development costs produced by CSIRO's Global and Local Learning Model (GALLM), based on the current technology costs prepared by Aurecon. The outcomes prepared by CSIRO are based on initial consultations with industry stakeholders in Q3 2019.

Feedback from this consultation will be provided to both CSIRO and Aurecon for consideration prior to finalisation of their reports, which will be used by AEMO in its 2020 forecasting and planning activities where appropriate.

Further details of the methodology and subsequent cost projections for new entrant developments are provided in the accompanying CSIRO GenCost 2019-20 Draft Report.

4.2   Generation fuel costs

AEMO engages independent consultants to project generator fuel costs, particularly coal and natural gas. These projections are provided by Wood Mackenzie (Coal) and CORE Energy (Natural Gas). The detailed forecasts are available in the following reports:

- Coal price forecasts: Wood Mackenzie (July 2019), available at the following direct link:
  - Wood Mackenzie Report
- Gas price forecasts: CORE Energy (December 2019), available at the following direct link:
  - CORE Energy Report

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[19] 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

4.3   Demand-side participation

The key assumptions that apply to AEMO's demand side participation (DSP) forecasts relate to:

- Types of DSP that are included or excluded in AEMO's forecast, and
- How DSP changes over the outlook period.

Inclusions and Exclusions

AEMO's estimation and forecasts of DSP aim to account for market-driven and reliability event responses by electricity consumers or generators, where the responses are not already accounted for in its demand forecasts or supply models. Specifically:

- AEMO assumes that customer responses that have been observed to be consistent and routine, and not in response to a price or demand trigger, would not materially change in the future. These consistent and routine demand activities are excluded from DSP and are instead incorporated in the regional demand forecast. They include daily load control (residential controlled hot water heating, for example) and businesses where demand fluctuations follow a consistent pattern from day to day, for example, in response to time-of-use tariffs.

- Reliability and Emergency Reserve Trader (RERT) responses are excluded from DSP as they are assumed to be active in demand response only when triggered by the RERT program. This is because these non-market responses are procured by AEMO specifically to address potential reliability gaps. AEMO's reliability forecasts (including DSP effects) need to consider supply and demand without these responses, so any reliability gaps can be detected.

Estimating current DSP response

DSP is a probabilistic response in the sense that while the physical ability to respond may be the same over time, the actual response differs from time to time due to other factors. This includes major loads who may have to continue operating to meet order deadlines at times, but have flexibility in their operation schedule other times. It also depends on the trading position of the controlled entity. During high price events, DSP resources controlled by entities with "long" trading positions (they have more supply than customer demand for the period) may have less incentive to call on DSP than entities with a trading portfolio that is "short" (who would generally always use their DSP resources to reduce price exposure during high price events).

As the actual response differs from time to time, AEMO uses the distribution of the observed historical response from possible DSP resources (as reported annually to AEMO's DSPI portal) to estimate the likely DSP response for the coming year.

Table 17   Estimated DSP in the start year

Region	Scenario	Component	Detail / Impact
All regions	All	Estimated DSP in start year	AEMO uses three years of history (or more if required to get enough observations to reasonably estimate the average (median) response for the different price and reliability triggers)

DSP projection assumptions

While AEMO's reliability studies only assume current levels of DSP (analogous to only considering existing and committed generation is available to meet demand), AEMO's longer-term planning studies, like the ISP, use a forecast of how DSP may evolve in the future, and apply a scenario-based approach to the forecast contribution.

For long-term planning studies, the DSP forecast is obtained by growing current DSP levels to meet an assumed level of activity by the end of the outlook period. This level:

- Is defined as the magnitude of DSP relative to maximum demand (MD) and linearly interpolated between the beginning and ends of the outlook period.
- Reflects scenario assumptions and state-specific features where necessary.
- Is determined through review and analysis of NEM and international DSP potential.
- The ISP forecast of DSP also includes an estimated response of 150 MW from Queensland coal seam gas (CSG) facilities from 2019-20 (for the reliability response trigger only). This response is excluded from reliability studies as it is not committed, nor has it been historically observed. Its inclusion in the ISP reflects AEMO's assumption that established CSG facilities now have the capability to reduce demand if incentivised, and this reduction may be triggered for prices observed under Lack of Reserve (LOR) 2 or 3 conditions.

Table 18   Assumptions used in DSP forecasting

Region	Scenario	Component	Value	Detail / Impact
All	Slow Change	DSP as a % of maximum demand under market price cap conditions by 2050	Low (continue current % of MD)	Reflects scenario assumptions and state-specific features where necessary.
All	Central	DSP as a % of maximum demand under market price cap conditions by 2050	Moderate (4.88% of MD)	Reflects scenario assumptions and state-specific features where necessary.
All	Fast change	DSP as a % of maximum demand under market price cap conditions by 2050	Moderate (4.88% of MD)	Reflects scenario assumptions and state-specific features where necessary.
All	High DER	DSP as a % of maximum demand under market price cap conditions by 2050	Moderate (4.88% of MD)	Reflects scenario assumptions and state-specific features where necessary.
All	Step Change	DSP as a % of maximum demand under market price cap conditions by 2050	High (8.5% of MD)	Reflects scenario assumptions and state-specific features where necessary.

4.4   Reliability and maintenance

AEMO models the reliability of dispatchable generation by applying forced outage parameters based on information provided by participants. AEMO collects information from all generators via an annual survey process on the timing, duration, and severity of historical unplanned forced outages. This data is used to calculate the probability of full and partial forced outages for each financial year.

In reliability modelling, AEMO applies four sets of outage parameters based on the previous four years of outage data provided. The outage parameters are applied at a station level for thermal generators (except small peaking plan with units smaller than 150 MW which are aggregated due to the small sample size on which to assess their performance). In longer-term modelling, the average of the previous four years is used to determine reliability parameters.

After the data is collected from participants, participants are provided the opportunity to propose evidence-based revisions to the parameters that are used in the ESOO modelling. AEMO takes any proposed revisions under consideration and may adjust the assumptions used in modelling.

Table 19 shows the aggregated outage assumptions. AEMO publishes outage parameters aggregated by technology to protect the confidentiality of this data.

Table 19   Forced outage assumptions

Generator aggregation	Full outage rate	Partial outage rate	Partial derating	MTTR – Full outage (hours)	MTTR – Partial outage (hours)
Brown coal	5.43%	11.65%	19.09%	47	6
Black coal QLD	2.30%	13.12%	17.59%	56	17
Black coal NSW – pre-2022	6.22%	26.06%	19.83%	137	20
Black coal NSW – after 2022	4.30%	23.84%	17.51%	104	17
CCGT	1.73%	0.19%	36.25%	23	29
OCGT	1.26%	0.35%	11.96%	7	40
Small peaking plant	3.52%	0.39%	7.18%	16	35
Steam Turbine	3.30%	0.01%	12.58%	89	64
Hydro	2.34%	0.39%	35.74%	17	5

More information on generator reliability settings and maintenance of both existing units and new entrant technologies, as provided in AEMO's 2019 Input and Assumptions Workbook, and outlined in the Aurecon 2019-20 technical parameter review for new entrants. Assumptions include:

- Forced outage rates and repair times by technology type.
- Reliability settings for new generation technologies.
- Refurbishment schedules.

Generator reliability settings (referring to full and partial forced outages and repair times) are considered for all thermal generation technologies (coal, gas powered generators, hydro and liquid fuelled generators) and energy storage systems. The reliability of renewable generation technologies is incorporated within the generation profiles of each renewable profile. This captures the derating of large wind and solar farms throughout the period with the outage of individual turbines or panels.

4.5   Plant operation characteristics

Understanding how individual generator units are likely to operate is important to assess the ongoing operability of the power system. Relevant inputs in AEMO's 2019 Input and Assumptions Workbook that AEMO would value feedback on include:

- Assumptions on the technical envelope of generators (ramp rates, minimum time online, minimum time offline, minimum stable levels). AEMO acknowledges that investment and operational decisions that impact these assumptions may be actively being considered by generators currently.

5. Supporting Materials

Supporting materials for these forecasts include the following sources. This Consultation Paper does not explicitly draw out all inputs and assumptions contained within these sources, however the methodology papers and supporting reports should be considered as part of the overall content that may influence stakeholder submissions.

Table 20   2019-20 supporting forecasting materials

Supporting report	Affecting	Source Location
CSIRO, GenCost 2019-20: Preliminary results for stakeholder review (NEW)	Supply Modelling – hydro availability forecasts	CSIRO GenCost 2019-20 Report
Aurecon, 2019 Costs and Technical Parameter Review (NEW)	Supply Modelling – hydro availability forecasts	Aurecon Report Aurecon Databook
CORE Energy, 2019-20 Wholesale Gas Price Outlook (NEW)	Supply Modelling and Gas forecasting	CORE Energy Report CORE Energy Databook
Deloitte Access Economics, 2019 Long Term economic scenario forecasts	Demand Forecasting – annual consumption and Max/Min Demand	Deloitte Report
CSIRO, 2019 Projections for Small Scale Embedded Technologies Report	Demand Forecasting – annual consumption and Max/Min Demand	CSIRO DER Report
Energeia, Distributed Energy Resources and Electric Vehicle Forecasts Report	Demand Forecasting – annual consumption and Max/Min Demand	Energeia DER Report
Strategy Policy Research, 2019 Energy Efficiency Forecasts	Demand Forecasting – annual consumption (energy efficiency and fuel switching)	SPR Report
Wood Mackenzie, 2019 Coal Cost Projections	Supply Modelling – fuel cost forecasts	Wood Mackenzie Report
Entura, 2018 Pumped Hydro Cost Modelling	Supply Modelling – hydro availability forecasts	Entura Report
AEMO, 2019 Inputs and Assumptions Workbook	Key assumptions used by AEMO in the 2020 Draft ISP	2019 Input and Assumptions Workbook

6. Additional feedback

Submissions are not limited to the specific consultation questions contained in each chapter, and not all questions are expected to be answered in each submission. AEMO welcomes written submissions on any inputs and assumptions used by AEMO to forecast supply and demand for use in ESOO or ISP.

Additional feedback requested:

Can stakeholders provide evidence to help guide development of future inputs, and illustrate where current inputs are no longer appropriate, for:

- Annual energy consumption forecasting of:
  - Residential consumption and its components
  - Business consumption and its components
  - Trends and impacts affecting both sectors, including climate change impacts and DER
- Maximum and minimum demand forecasting, including:
  - Energy efficiency saturation
  - Demand trace assumptions
- Modelling the energy supply, including:
  - Generation costs and technical parameters
  - Future costs of new generation technologies
  - Demand side participation that may avoid the development of physical supplies
  - Reliability settings appropriate for existing and new generation technologies
  - Operational characteristics of existing and new generation technologies