AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

National Electricity Market Demand Forecasting Methodology

February 2019

Final Report and Determination

Important notice

PURPOSE

The publication of this Final Report and Determination concludes AEMO's consultation on the effectiveness of its 2018 Demand Forecasting Methodology Paper in describing in adequate detail the methodologies for forecasting annual consumption, and maximum and minimum demand in the National Electricity Market (NEM), for use in planning publications such as the NEM Electricity Statement of Opportunities (ESOO) and Integrated System Plan (ISP).

This publication has been prepared by AEMO using information available at 17 December 2018. Information made available after this date may have been included in this publication where practical.

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VERSION CONTROL

Version	Release date	Changes
#1	28/2/2019	

Notice of Final Determination

Date of Notice: 28 February 2019
This notice informs all interested parties that AEMO has completed its consultation to amend the 2018 Demand Forecasting Methodology Information Paper.

Determination and Publication
AEMO's final determination is the Electricity Demand Forecasting Methodology Information Paper in the form published on the AEMO website[1].

[1] Available at: http://aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/NEM_ESOO/2018/Electricity-Demand-Forecasting-Methodology-Information-Paper.pdf (Accessed 28 February 2019)

Executive summary

The publication of this Final Report and Determination concludes the consultation process conducted by AEMO to consider the effectiveness of its 2018 Demand Forecasting Methodology Information Paper (Methodology Paper) in communicating AEMO's electricity forecasting approach.

The Methodology Paper explains the data sources and methodologies used to forecast annual consumption, and maximum and minimum demand in the National Electricity Market (NEM). AEMO uses the forecasts in publications such as the NEM Electricity Statement of Opportunities (ESOO).

AEMO is committed to publishing forecasts that are credible and dependable. We continually seek to improve the forecasting methodologies, and recognise the importance of industry expertise, insights and feedback.

AEMO began the consultation process on 7 November 2018, with the publication of an Issues Paper. The Issues Paper sought industry feedback on whether the Methodology Paper improves transparency of AEMO's forecasting approach, adequately explains and justifies inputs, provides sufficient detail to understand the methodology, and adequately captures recent issues or influences that may affect forecast components. AEMO subsequently held an industry workshop on 13 November 2018 and invited written submissions until 28 November 2018.

AEMO received a significant number of submissions from stakeholders. This Final Report and Determination forms AEMO's response to the submissions. Many submissions have assisted in improving the communication of AEMO's forecasting methodology. Some submissions suggested methodological changes, which were outside the scope of the Issues Paper, and may be considered by AEMO at a later time.

AEMO's Final determination is the *Electricity Demand Forecasting Methodology Information Paper* in the form published on the AEMO website.

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1. Stakeholder consultation process

AEMO consulted on the effectiveness of the 2018 Demand Forecasting Methodology Information Paper (Methodology Paper) in describing, in adequate detail, the methodologies for forecasting annual consumption and maximum/minimum demand in the NEM, for use in planning publications such as the NEM Electricity Statement of Opportunities (ESOO) and Integrated System Plan (ISP). AEMO's timeline for this consultation is outlined below.

Table 1 Consultation timeline

Deliverables	Dates
Issues Paper published	Wednesday 7 November 2018
Industry Workshop	Tuesday 13 November 2018
Submissions due on Issues Paper	Wednesday 28 November 2018
AEMO response	Thursday 28 February 2019

This Final Report and Determination represents AEMO's response to the feedback received. The date for AEMO's response has been revised to 28 February 2019, due to the extent of issues raised during the consultation process.

2. Background

AEMO recognises that its energy and demand forecasts support investment decisions in Australia's energy markets. The forecasts must be credible and dependable, and we continually seek to improve our forecasting methodology. Industry expertise, insights, and feedback help to address the challenges of forecasting, particularly in a rapidly changing energy industry. AEMO is committed to improving the transparency, accountability and accuracy of its forecasts.

On 26 September 2018, AEMO published the Methodology Paper to explain the inputs, assumptions, and methodologies used to develop AEMO's electricity forecasts.

On 7 November 2018, AEMO released an Issues Paper to seek feedback on whether the Methodology Paper provides sufficient information to enable interested stakeholders to understand the forecasts. AEMO subsequently held an Industry Workshop on 13 November 2018 to discuss the Issues Paper.

The Issues Paper invited stakeholders to respond to the following questions:

1. Does it help improve transparency of AEMO's approach to forecasting annual consumption, maximum demand, and minimum demand in the NEM? What more could practically be done to ensure the forecasting process is well understood, and build greater confidence in the forecasts for decision-makers?
2. Does it adequately explain and justify the choice of inputs and drivers used for each forecast component?
3. Is the level of detail provided sufficient to allow you to understand the methodologies applied? Is the annual energy consumption forecasting approach adequately explained? Are the maximum and minimum demand forecasting approaches adequately explained? If not, what additional information/explanations are required?
4. Does it adequately capture any recent issues or influences affecting each forecast component? Are there any data quality or data latency issues with the data sources used?

AEMO received feedback from eighteen stakeholders (see Table 2), in the form of written submissions, and as documented in the Workshop minutes[2].

Table 2 List of stakeholders providing feedback

Organisation	
AEC	Origin
AER	Public Interest Advocacy Centre
Ausgrid	Powerlink
Endeavour Energy	SA Department of Energy and Mining (DEM)
Energy Queensland	SA Department of Premier and Cabinet (DPC)
EnergyAustralia	SA Department of State Development (DSD)
Engie	SA Power Networks
ERM Power	Stanwell
NSW Department of Planning and Environment (DPE)	Sliger & Associates

[2] Workshop minutes available at: http://aemo.com.au/-/media/Files/Stakeholder_Consultation/Consultations/NEM-Consultations/2018/NEM-Demand-Forecasting-Methodology---Industry-Workshop-Minutes.pdf (Accessed 28 February 2019)

3. Stakeholder feedback and AEMO's response

AEMO received widespread support for publication of the Methodology Paper, and recognition that it improved transparency of AEMO's forecasting approach. The feedback has assisted in revising the Methodology Paper and better communicating AEMO's forecasting methodology to interested stakeholders.

The feedback was wide-ranging, and covered topics listed in Table 3.

Table 3 Summary of topics

No	Topics	Location in this report
1	Data inputs and assumptions	Table 4
2	Consumer segmentation	0
3	Maximum and minimum demand	Table 6
4	Half-hourly demand traces	Table 7
5	Electricity retail pricing	Table 8
6	Weather and climate	Table 9
7	Rooftop PV and energy storage	Table 10
8	Electric vehicles (EVs)	Table 11
9	Energy efficiency (EE)	Table 12
10	Other	Table 13
11	Presentation of results	Table 14
12	Report content	Table 15

Tables 4 to 15 provide a summary by topic of the feedback received and AEMO's response. A significant number of comments were considered outside the scope of the Issues Paper, providing suggestions for potential change to the methodologies AEMO applies.

AEMO acknowledges the effort taken by stakeholders to provide feedback, and the potential for the feedback to improve the accuracy and accountability of our forecasting methodology in the future. We have therefore sought to respond to these comments in this Report.

Table 4 Data input and assumptions

Organisation(s)	Comment	AEMO Response
General		
Ausgrid	Make available a more 'open source' forecast with all data sources, procedures and assumptions transparently published to allow stakeholders to test each forecast	The Methodology Paper sets out the information AEMO uses to develop forecasts. AEMO will continue to review the information provided to stakeholders, however, is restricted from publishing all data sources due to commercial in confidence issues, as well as the large volume of data used in developing the forecasts.
Energy Queensland	There is industry-wide benefit from providing a fully-functional or 'live' model with easy access to input data and key assumptions, and a standardised format to allow users to exchange ideas and models. This would facilitate replication and innovation	
Endeavour Energy	Explain and justify in more detail the choice of inputs	AEMO has provided further justifications and explanations throughout this report in response to specific feedback provided by stakeholders.
Business sector		
Ausgrid, NSW DPE	Provide further information on the survey process, including process for determining sectors to be surveyed, survey questions, response rate, and aggregated results	AEMO uses targeted interviews and requests forecasts from the largest industrial energy users with a threshold of the user having at least 10 MW demand for at least 36 days in the year (approximately 10% of days in a year), across all energy users irrespective of the energy sector. The updated Methodology Paper now explains in more detail AEMO's survey process.
NSW DPE	A survey-based approach would have a limited timeframe and may not be appropriate for a long-term 20-year forecast	AEMO's survey process investigates the trajectory of consumption of industrial users across the forecast horizon, considering short-, medium- and long-term economic drivers and adjusting the trajectories to be consistent with those economic drivers.
Energy Queensland	Provide economic and other assumptions for each sector, including those sectors which are surveyed. It is also important that survey assumptions are in line with assumptions used elsewhere to create forecasts.	AEMO engages an independent economic consultant to identify appropriate assumptions across sectors, and applies these consistently in determining each sector's forecast. Surveyed participants are also provided with these consistent economic indicators to align the trends of the surveyed and econometric-forecast sectors. In future, a public version of the report provided by the economic consultant will be published as supplementary materials.
Residential sector		
Engie	Factor in the significant growth in smart home systems and appliances	Suggested methodology change. Methodology change suggestions will be considered for improvements in future forecasts.

Organisation(s)	Comment	AEMO Response
ERM Power	Reconsider inclusion of the 'adjustment factor' assumption to account for bigger electrical appliances than currently or historically installed which increases forecasted demand; rather older appliances may be replaced with newer more efficient models which reduce demand. AEMO should access independent data to validate this assumption.	The methodology report provides perspective of the capture of these effects for residential consumers, including the size of appliances (outlined in Step 2.1 of the residential method). Step 2.6 then outlines the efficiency impacts over time, considering the consistent appliance uptake projections.
ERM Power	AEMO calculates average consumption and half-hourly demand by dividing total residential consumption by the no. of connection points. Are connection points disaggregated by type (for example, detached, semi-detached and apartment) or by use type (for example, owner occupier, rental and holiday)?	The data does not currently allow disaggregation by connection type or by use type. AEMO is currently working on sub-regional meter data analysis to enhance the understanding of consumption and provide finer granularity. AEMO is also working with the CSIRO[3] to improve capability in this area.
ERM Power	AEMO should consider usage diversification during working hours and holiday periods, where temperature sensitive demand is not a factor	AEMO differentiates usage for the Maximum/ minimum demand models. The annual consumption model contains workday and non-workday variables; further breakdown is not being considered at this stage.
SA DEM	Does AEMO distinguish between new and existing connection points, given they have materially different consumption patterns? How is evolving housing stock incorporated into the forecasts?	AEMO has investigated meter data for new and existing connections and identified large differences in consumption due to dwelling size and age. The regression models are trained on only recent years of consumption data to reflect the current balance of new/existing and greenfield/metro customers. AEMO will consider the potential for refinements to this approach in future forecasts to adjust the long-term balance of consumer dwelling demographics.
Variables		
Energy Queensland	AEMO uses dummy variables, which increase goodness-of-fit. It would be useful to document assumptions on what is captured (for example, technology adoption, business confidence) and expectations for that assumption in the future.	AEMO will consider publication of details of the regression fits in future issues of the methodology paper, or Forecast Accuracy Reports, to show the goodness-of-fit and other accuracy measures. All variables in the regression models are listed in the relevant chapters for the residential and business sectors.

[3] https://www.csiro.au/en/Research/EF/Areas/Electricity-grids-and-systems/Economic-modelling/Energy-Use-Data-Model (Accessed 25 February 2019)

Table 5 Consumer segmentation

Organisation(s)	Comment	AEMO Response
NSW DPE, Energy Queensland	Econometric modelling may not be the best approach for all sectors, for example, urban rail and data centres	AEMO segments where consistent and reliable data can be obtained with sites verified. AEMO will consider the degree to which alternative data sources can be used to expand the industrial survey model to reduce the breadth of sectors captured in econometric modelling. Current econometric modelling does consider regional infrastructure projects, such as rail. Although GSP will explicitly contain investment information that will include stated government investment such as rail or regional projects, AEMO will investigate whether further segmentation of the business sector is feasible (for e.g. availability of consumption data and the size of sector).
ERM Power	Include subcategories in 'Other Business' for rail services, schools, hospitals or data centres, which have specific consumption shapes, to improve accuracy.	
Engie	Split the residential and business categories	Annual consumption is already split for these sectors
Stanwell	Is the residential/business split only applied for the base year, or does it change over time?	The residential/business split is applied in the first year. After the first year the different demand drivers will determine what the total for the business and residential components will be for each subsequent period in the forecast.
Sliger & Associates	Add desalination plants to large industrial installations	Suggested methodology change. Some desalination plants have previously declined an interview. AEMO will continue to contact large users for future models.

Table 6 Maximum and minimum demand

Organisation(s)	Comment	AEMO response
AEC	The Paper does not review weather corrected actual performance with maximum demand forecasts	The latest Forecasting Accuracy Report (now linked in the Methodology Paper) has been expanded compared with previous versions and now addresses this question.
Endeavour Energy	Are there any multicollinearity issues with using CD, HD, CD^2 and HD^2 in the model?	The methodology document describes how multicollinearity between variables is tested and removed from the model by considering the correlation between variables and the variance-inflation-factor. For using CD, HD, CD^2 and HD^2 in particular, these variables have been constructed not to be collinear and could all be included.
Endeavour Energy	Consider splitting model into two, for summer and winter, to improve performance. HD has little impact on summer demand and CD has little impact on winter demand.	Indicator variables and the CD and HD variables are used to stratify the data into seasons and weekdays/weekend. So in practice the model is split into different models.
Endeavour Energy	Does AEMO have any adjustment to address the issue of temperature discontinuity between two weather blocks? There could be an unrealistic step change of temperature at the boundary between two blocks.	The Methodology Paper has been expanded with further explanation on the block-bootstrapping approach, including why it is not required to smooth temperatures with the current methodology.

Organisation(s)	Comment	AEMO response
Endeavour Energy	Does AEMO assume that maximum demand and annual consumption grow at the same rate? If so, can AEMO justify this assumption?	AEMO has updated the Methodology Paper to provide further explanation on the two different growth methods for annual consumption and maximum/minimum demand in the methodology document noting how it allows the load factor to change over time and the implicit application of energy efficiency and price impacts on growth.
Endeavour Energy	How does AEMO apply the energy efficiency adjustment to maximum demand?	
Endeavour Energy	How is electricity price impact incorporated in the maximum demand forecasts?	
EnergyAustralia	Is an annual growth index applied to every single half hour of every simulation? If so, why not apply the annual growth index just to the POE level of a standard year?	
EnergyAustralia	Many 'economic conditions' (e.g. retail price) are actually variables. What consideration does AEMO give to these variables?	
Energy Queensland	Weather normalisation seems to be used interchangeably with the National Electricity Rules' (NER) POE concept, however the NER do not specify that POE is exclusively weather dependent. Consider clarifying 'weather normalisation' and/or differentiating it from POE.	AEMO has updated the section to ensure it is consistent with the industry usage of the term.
Endeavour Energy	The impact of minimum demand differs depending on the location within the network. It should be recognised that the timing, types of challenges, and modelling and forecasting required as a result of minimum demand are different.	AEMO is developing a process to forecast minimum demand at Connection Point level for planning purposes.
Engie	The methodological description to simulate peak demand lacks detail. Replace generic distribution curves in Fig. 10 with actual results, illustrate goodness of fit to show actual demand points on a distribution function, and specifically show how it captures the 'peak' part of the demand accurately.	The accuracy of the method is addressed in the Forecasting Accuracy Report (now linked in the Methodology Paper).
EnergyAustralia	Further breakdown maximum demand POE levels by segment, i.e. split residential and commercial	AEMO currently doesn't have metering data at half-hourly level to support such a split.
ERM Power	Consider publishing monthly maximum demand forecasts rather than seasonal to help better planning of supply side outages, demand management activities, and improve accuracy of reliability assessments. Historical demand traces would also be more accurate if adjusted from monthly based forecasting set points.	This suggestion will be considered as improvement in future forecasts. AEMO is actively considering the capacity to increase granularity in the max demand forecasts. In addition, AEMO is working on calculating the counterfactual demand in the absence of load shedding, demand management, etc.

Organisation(s)	Comment	AEMO response
ERM Power	Provide more details on how AEMO derives 1000 years of possible half hourly demand traces from 1000 years of simulated weather data. For e.g., publish 10, 50 and 90% POE of daily maximum temperatures from AEMO's model for the initial forecast year on a monthly timescale and compare with historical BOM data.	The way AEMO constructs its 1000 weather years is constructing each such year from sampling and combining historical 14-day blocks in a way that preserves the historical distribution of weather outcomes. On top of that, climate change adjustments are applied.
ERM Power	AEMO applies an Excess Heating Factor (EHF) to modify forecast outcomes where daily maximum temperatures exceed the 95th percentile value for 3 consecutive days. Provide the 95th percentile value for the applicable weather stations, the EHF modification values, and how they are applied.	Methodology Paper has been updated to better reflect that EHF was a candidate variable for the maximum demand model, but was not selected in the final model, which rather used the rolling 3-day average temperature instead to represent the impact of extended hot weather. The methodology now also better explains the definition of the 95th percentile used for EHF.
ERM Power	For maximum demand, provide a further explanation on the input assumptions and calculated outcomes for HDD, CDD, average 'base' and 'temperature sensitive' demand, impact of rooftop solar PV, and energy reduction from EE schemes.	AEMO will include a waterfall diagram in the 2019 ESOO in the insight's sections of maximum demand.
ERM Power	Why do the maximum demand forecasts appear to be at odds with the maximum daily demand in the MT PASA?	The daily maximum demand in MT PASA is native as-generated and is for mid-summer exactly the same as the seasonal ESOO forecast when small non-scheduled generation is added. It should be noted that it is profiled based on observed highest weekly demand in the last five years relative to the annual observed max demand. For a particular day in a week, it therefore represents the level of demand that on that particular day would only be exceeded one year out of ten. Note also, this is very different to a definition that would have the forecast value exceeded one day out of ten.
FRG Workshop	Better explain demand side participation (DSP) and the effect on maximum demand.	The forecast maximum demand represents the forecast demand in the absence of DSP. DSP is treated as a source of supply and applied after maximum demand is calculated. The Methodology Paper now further explains this process.
Powerlink	Provide further details on how maximum and minimum demand is calculated. In QLD, a proportion of a large industrial customer's annual peak demand at time of regional maximum and minimum demand changes from year to year. Make the methodology more transparent on how such loads are incorporated, to take account load fluctuations at the time of maximum and minimum demand.	AEMO has added additional detail on how large industrial customers loads contribute to the coincident regional maximum demand.

Organisation(s)	Comment	AEMO response
SA Power Networks	The minimum demand methodology is not as clear as for maximum demand.	The methodology is the same for both minimum and maximum demand, as described in Section 5 "Maximum and minimum demand" of the Methodology Paper. The same half-hourly model is used and simulated with rooftop PV generation. The annual minimum demand from each simulated year is retained and used to form the POE distributions for minimum demand

Table 7 Half hourly demand traces

Organisation(s)	Comment	AEMO response
AER	Could AEMO provide a comprehensive example of how a load trace is developed	Appendix A8 of the Methodology Paper now contains a worked example. A reference to it has been added to the presentation of the methodology in Section 6.
AEC	Provide worked examples with real data and every step methodically shown, so that statistical approaches may be more fully grasped, eg regional maximum demand and 10 and 50% traces.	
Endeavour Energy	The Methodology Paper does not explain how the forecast process for a half hourly demand is actually done	
ERM Power, FRG Workshop	Make it clear that the trace growing algorithm scales the top 10 peak days, but only one value is grown to max demand value	AEMO has clarified this in the methodology document

Table 8 Electricity retail pricing

Organisation(s)	Comment	AEMO response
Ausgrid	Consultant reports appear dismissive in considering the potential implementation of cost-reflective tariff structures.	AEMO will request greater clarity on tariff structures and tariff popularity in future consultant reports.
Engie	Residential pricing changes need to be reflected in the methodology, e.g. changes to fixed and variable charges towards cost reflective network pricing. Past trends won't be useful in demand forecasting, since changes will lead to behavioural change.	AEMO's models consider the potential for tariff reform or customer retail churn to minimise customer price response. Price elasticity adjustments are outlined in the Methodology Paper. The adoption of time of use or cost reflective tariffs are considered to adjust timings of consumption rather than the total consumption patterns. The degree of DER uptake is influenced by tariff structures also, and is considered in the methodologies used by AEMO's consultants.

Organisation(s)	Comment	AEMO response
Endeavour Energy	Is there any consideration of future price impact on residential and commercial customers to adjust usage patterns?	Yes. Appendix A.1 in the Methodology Paper now provides further clarification that both sectors include a price elasticity component.
NSW DPE	Is price elasticity captured in the residential consumption forecast as it is in the business forecast?	

Table 9 Weather and climate

Organisation(s)	Comment	AEMO response
Endeavour Energy	What is the reason for using 9pm to 9pm the following day temperatures? How do the 'following day' temperatures impact 'today's' energy consumption?	This average was developed off regression models with different windows of temperature data that (in-part) accounted for capturing residual heat in the response from consumers to temperatures. Section expanded to clarify that the first 9:00 PM value is the previous day of interest until 9: PM of the current day of interest.
ERM Power	AEMO uses 6 weather stations in 5 capital cities to calculate temperature sensitive demand across the entire NEM, whereas other AEMO documents indicate up to 20 weather stations are used for forecasting purposes. The limited number potentially impacts the accuracy of the results.	AEMO's operational demand short term forecasting process uses multiple weather stations as important to capture change in temperatures over the day and the impact on demand. For a seasonal maximum demand forecast using a single representative weather station representing the capital cities gives a good model performance, but AEMO is investigating using more regional weather stations as a future model improvement, both for maximum/minimum demand and annual consumption forecasting.
ERM Power	Provide justification for why AEMO has not adopted the industry standard values for HDD and CDDs. Did AEMO consider a 'time of day' variable and solar radiation values in the decision process?	There are BOM standards of CDD and HDD of 18 and 21 degree cut-offs. AEMO uses cut-off temperatures that provide the best out-of-sample error testing for regression models.
NSW DPE	How is the climate adjustment factor implemented for maximum/ minimum demand forecasts?	See Appendix.23: Climate Change of the ESOO methodology document
ERM Power	Provide details on how the climate adjustment factor is calculated and the temperature trend that it is based on. Provide data to support that maximum temperatures are increasing at a known trend, and higher than the increase in the mean daily temperature.	

Organisation(s)	Comment	AEMO response
ERM Power	Does climate change adjustment include a saturation effect? Ie, at certain temperatures, energy efficiency savings are zero, leading to a linear increase in load relative to temperature.	The climate change adjustment is only made to temperature. The relationship between temperature and demand is captured by the demand model. AEMO is investigating whether 'conservation load factors' across different appliances would improve the distinction of energy efficiency savings across total energy consumption and peak consumption.
ERM Power	Publish calculated yearly climate change adjustment values on a monthly basis for each reference year	Climate change data is freely available at https://www.climatechangeinaustralia.gov.au/. This is outlined in Section 5.1 of the methodology.
Powerlink	Incorporate regional-specific methodology adjustments to account for varying population centres, industries, load distribution and weather patterns. For QLD, weather patterns vary considerably but AEMO uses one weather station to weather normalise maximum and minimum demand; consider using multiple stations to improve accuracy.	AEMO is actively investigating using more regional weather stations as a future model improvement, both for maximum/minimum demand and annual consumption forecasting.
Sliger & Associates	To consider hot days, look at the rate of change of temperature is succeeding days as a possible indicator of impending excessive temperature	AEMO uses BOM data for historical weather data and the CSIRO for modelled changes in weather from expected climate change effects. Regression models are tested against numerous weather data, including changes in temperature from previous data along with trialling standard weather indices (such as the BOM Heat Index).

Table 10 Rooftop PV and energy storage

Organisation(s)	Comment	AEMO response
Endeavour Energy	Provide more verification detail on assumptions used in forecasting methods, e.g. post model adjustments for rooftop PV	PV production is estimated using a solar irradiance and PV installed capacity model. Then, the different sectorial amounts are added to that sector (for example, section 3.2.2 details how the residential sector is modelled by adding estimates for PV generation onto the sector's grid consumption)
EnergyAustralia, FRG	How does AEMO estimate the underlying assumption by removing the impact of PV generation? Explain better whether PV is subtracted or added when moving from delivered to underlying consumption	
Endeavour Energy	Studies on solar battery charge and discharge profiles, their penetration rate, and battery size, will be useful.	AEMO is investigating available meter data to identify and quantify the impact of the potential role for battery storage.
EnergyAustralia	The choice of drivers is well explained, however, provide more detail on the choice of input assumptions. For e.g., how does AEMO test the accuracy of back calculated rooftop PV?	Refer to the Forecasting Accuracy Report for an assessment of accuracy and back-testing

Organisation(s)	Comment	AEMO response
EnergyAustralia **ERM Power**	Provide justification for the 20% PV rebound effect assumption. Is there a plan to back-test this assumption?	AEMO continues to investigate customer meter data, isolated for solar PV sites, to test this assumption.
EnergyAustralia	There is significant uncertainty on the impact that rooftop PV and energy storage will have on future demand. Provide more detailed data to allow stakeholders to perform further sensitivity/ scenario analysis	AEMO will consider the depth of data released for each forecast update. This will include publishing traces for rooftop PV, energy storage and electric vehicles separately so that stakeholders can replace these assumptions with their own views.
ERM Power	AEMO assumes all panels face north, but this may shift to a westerly orientation.	Appendix A3.1.2 describes AEMO's approach to rooftop PV orientations, with an increasing uptake of west-facing panels to increase afternoon and evening production. AEMO has now entered into an agreement to receive additional estimations of generations from panels of different orientation, and where appropriate will update the PV generation model with this new information.
ERM Power	AEMO's output appears to be based on the panel installation value, but this could overestimate PV contribution as it is common practice to have 15-25% more panel capacity than inverter capacity. It may also underestimate PV contribution to summer peak demand, as inverters continue to contribute later and at higher output levels than that modelled by AEMO	AEMO's PV forecast represents the output to AC (limited by inverter size). This capacity is multiplied by a normalised generation profile, based on historical insolation but also calibrated to actual observations (from pvoutput.org and gross-metered systems in NSW). The energy produced should therefore closely match that of the existing portfolio of rooftop PV systems, but may have more uncertainty at times outside the solar peak. AEMO will continue to refine its methodology, eg through new data feeds from Solcast and improved visibility of inverter size vs panel capacity once the DER register is in place.
AER	It is unclear where batteries fit into the definitions of grid demand	The Key Definitions section of the Methodology Paper has been updated to improve clarity on definitions of demand, and the inclusion of 5 MW or higher for batteries.
Ausgrid	Assumptions around battery storage are not adequately clarified in the Methodology Paper and Consultant's reports. There appears to be little testing of approaches adopted.	Details of consultants work for battery storage are to be enhanced in the upcoming 2019 forecasts
Energy Australia	AEMO assumes all systems act to minimise costs at an individual/household level. This assumption may not hold true going forward, e.g. virtual power plants. We would appreciate AEMO completing modelling on centrally-coordinated behaviour and make it possible for stakeholders to run scenarios on the uptake of such systems.	AEMO applies scenario analysis on the uptake of aggregated battery systems, or virtual power plants, in the broader assessments in the ESOO and Integrated System Plan (ISP). AEMO still forecasts the individual/ household level battery usage separately, which is subtracted from the forecast operational maximum demand forecast. Aggregated battery systems are treated as a potential supply source, and are modelled explicitly (and therefore the demand forecasts are gross of these impacts).

Organisation(s)	Comment	AEMO response
ERM Power	How will consumption associated with large scale batteries or pumped storage hydro be captured and reported on, as they are installed?	Auxiliary loads associated with large scale storage systems are not explicitly captured in the demand forecast targets as the installation timing and operation of these potential systems is uncertain. In modelling the supply needed to meet demand in outlooks such as the Integrated System Plan, the prevailing generation operational outlook considers both the forecast demand targets and resulting auxiliary load attributed to generation technologies during dispatch. Auxiliaries associated with storage systems, including pumped hydro and battery systems, are included in calculating the energy provided and/or consumed by these systems when operating.
FRG	How is battery load treated in operational consumption?	The Key Definitions section of the Methodology Paper has been updated to improve clarity on definitions of demand, and the inclusion of 5 MW or higher for batteries.
FRG	It is unclear how battery curves have been applied. What profile/tariff is used in each region?	Specific outcomes of the forecasts are provided in the released forecasts. For example, in the 2018 ESOO.

Table 11 Electric vehicles

Organisation(s)	Comment	AEMO response
Ausgrid	Assumptions around EVs not adequately clarified in the Methodology Paper and Consultant's reports. There appears to be little testing of approaches adopted.	AEMO appreciates the method for forecasting EVs provides less detail than stakeholders request. AEMO's 2019 forecasts are seeking to address this, and will be running workshops with industry to help validate assumptions.
Endeavour Energy	Studies on EV charge and discharge profiles, their penetration rate, and battery size, will be useful.	These forecast outputs are provided in the reports publishing each forecast, e.g. the ESOO2018 report.
Engie	Multiple futures are likely, however current assumptions on battery storage, EVs and charging scheme consider one possibility only. Other possibilities include hydrogen, incentive to charge during the day due to PVs, etc.	Suggested methodology change. Methodology change suggestions will be considered for improvements in future forecasts.
ERM Power	AEMO should assess alternative electric vehicle futures, including hydrogen (directly injected into an advanced combustion engine or in a fuel cell)	AEMO is exploring assumptions on charging behaviours in a dedicated EV workshop with industry on 4 March 2019
ERM Power	What breakdown of EV charging will be captured under business consumption? Would this include all large scale multi vehicle charging stations, or only charging stations at business premises?	.

Organisation(s)	Comment	AEMO response
ERM Power	AEMO assumes 40% of EVs are charged once garaged. This may not consider the impact of technology, e.g. smart meters and retail tariff incentives on consumer choice to charge outside of higher demand period.	AEMO used the scenario bounds of Fast, Neutral and Slow to test the impact of charging in and outside the higher demand periods. Refer to ESOO 2018 paper.
FRG	It is unclear how EV curves have been applied. What profile/tariff is used in each region?	Available in the ESOO2018 main report and supporting materials.
Sliger & Associates	Less reliable/ more contentious components, for e.g. EVs, could be collected and development shown as a separate curve acknowledged to be far more open to major change. The curve could provide some explanation for perceived lack of clarity over time.	AEMO has modelled this item as a separate item for both annual consumption and max/min demand. The breakdown can be found http://forecasting.aemo.com.au/
Sliger & Associates	AEMO relies on the CSIRO for values and predictions. Consider seeking other sources, esp. for more contentious matters, such as the growth of EVs.	AEMO will be seeking projections from two independent consultants to inform the 2019 forecasts.

Table 12 Energy efficiency

Organisation(s)	Comment	AEMO response
Ausgrid, ERM Power, SA DSD	Provide more explanation for why AEMO applied a 40% rebound effect, ie only 60% of the forecasted energy savings was applied.	Detail of 40% was noted in main ESOO report. Details on this adjustment can be found in section 2.2.4 of the methodology report.
Endeavour Energy	If calibration against estimated EE savings and observed metered consumption shows a large discrepancy, does that mean there is something wrong with the method used to calculate the 'energy efficiency adjustment'?	Section 2.2.4 has been enhanced. Current snapshots of electricity consumption reflect current energy efficiency trends observed through meter data analysis. Additional energy efficiency savings relative to the latest year of consumption are applied to the forecast. The energy efficiency adjustment factor reflects the efficiency savings forecast for future years, rather than those identified since 2000, as forecast in the raw EE forecast. The period of the adjustment is equal to the period of the regression model training (approximately 3 years)
Powerlink	Provide more clarity on how EE is incorporated, including additional detail on the sensitivity of future EE gains.	
Endeavour Energy	Provide more verification detail on assumptions used in forecasting methods for annual and maximum demand, e.g. post model adjustments for EE	Verifications of the forecasts are reported on in the ESOO and Forecast Accuracy reports. Section 2.2.4 has been enhanced when describing energy efficiency, climate change and rooftop PV adjustments. AEMO will look to provide more clarity on assumptions in future forecasts.
Endeavour Energy	There aren't many details regarding EE impacts on peak demand in the Consultant's report.	AEMO will request its consultants expand the content provided in future reports to address these concerns.

Organisation(s)	Comment	AEMO response
ERM Power	Further explanation is required on the relationship between annual consumption and maximum demand in the context of EE	
FRG	How is EE apportioned to heating, cooling and base loads?	AEMO uses the total EE savings as forecast by our Consultant, and applies these total savings across the heat/cool/base categories in accordance with historical consumption analysis. AEMO continues to investigate methods for improvement in EE savings.
Endeavour Energy	Has AEMO conducted studies on peak demand impacts from the replacement of old air conditioners to more efficient ones of similar capacity on hot summer days? Results would be useful for EE adjustment for maximum demand.	There are not many studies looking into this subject available. AEMO currently applies an average energy efficiency saving at time of maximum demand because increasingly peak demand is occurring later in the day after the air-conditioners have been on for a few hours.
NSW DPE, SA DPC	State departments have data that could assist with improving EE forecasts	AEMO welcomes assistance from stakeholders, and will follow up with State departments that have offered to provide data on energy efficiency schemes.

Table 13 Other

Organisation(s)	Comment	AEMO response
AEC	Methodology Paper does not cover short-term demand forecasting	The scope of the Forecasting methodology document covers the methodology for the medium/long term assessments used in Forecasting and Planning analysis, such as the ESOO and ISP.
AEC, Stanwell	Methodology Paper does not cover demand side response	Forecast maximum demand assumes no DSP at time of peak demand – representing what forecast maximum demand would be in the absence of DSP. To supplement this, AEMO produces separate forecasts for DSP for different price levels and reliability triggers. These have in recent years been published separately from the demand forecast and therefore not included in the methodology document, with the method briefly discussed in the DSP forecast documents itself. AEMO will consider merging the DSP documentation into the wider forecast methodology document in the future.
Engie	The Methodology document should provide sufficient detail for participants to replicate results and/or make changes to produce new demand which is consistent with AEMO's demand projections.	The Methodology Paper's purpose is to provide this detail to the extent practicable, while the purpose of this Consultation is to assess its achievement of this objective. However, the volume of input data, and confidential information makes it difficult for other stakeholders to precisely replicate AEMO's forecasts.

Organisation(s)	Comment	AEMO response
Engie	The Accuracy objective is inappropriate, because of the long forecast period and increasing uncertainty spanning policy, technology, economy and customer preference	The Forecast Accuracy Report particularly examines the accuracy of the last year forecast.
ERM Power	The naming of the demand forecast reports are confusing, with reports titled SOO, ESOO, NEFR and NEFI. Suggest all future annual reports be released as the 'National Electricity Forecasting Report - NEFR'.	AEMO has moved away from preparing separate NEFR documents, with feedback received from stakeholders that it is more meaningful to consider demand and supply implications in a single document (such as the ESOO). As material new information comes to hand, AEMO is committed to updating its forecast and will publish any update on its forecasting portal with a brief explanation. AEMO has now developed a separate demand forecasting page on its website to allow stakeholders to track the various forecasts as developed.
PIAC	Enhance accessibility and understanding of forecasting results, assumptions and limitations, and transparency of modelling e.g. discuss the various drivers underlying the forecasts.	The Methodology Paper aims to increase stakeholder's understanding of AEMO's demand forecasting approach, and is being updated based on specific feedback from this consultation process.
Sliger & Associates	Did the paper discuss daylight savings and the complexities between States?	All forecasts are done on a consistent NEM time basis. When drawing out insights there may be instances where the times are provided in local format. Supply assessments capture the inter-regional impact of different time zones and coincident demands.

Table 14 Presentation of results

Organisation(s)	Comment	AEMO response
ERM Power	Historical operational demand data from earlier AEMO forecasting reports have altered without an explanation in subsequent NEFR/NEFI/ESOO reports.	Some data updates have been noted in releases, but it is acknowledged that a more effective way to communicate this should be considered where future changes are required.
ERM Power	NEFR/NEFI/ESOO contain no comparison of actual historical data with most recent forecasts immediately prior to the applicable summer or winter period. Suggest including min 10 years of historical data, reporting both actual and forecast at the time for 10, 50 and 90% POE, to allow parties to compare actual and planning forecast outcomes.	The forecasting portal (http://forecasting.aemo.com.au/) provides the capacity to compare historical actual data against forecasts for comparison purposes. The Forecasting Accuracy Report assesses performance of most recent forecasts against actual data, and is an important step for AEMO to assess and potentially recalibrate or modify its forecasts.
ERM Power	Data should be easy to retrieve via a dedicated link on AEMO's website included in each successive NEFR as it is released, and also via AEMO's Forecasting Demand Data Portal	AEMO have now provided a guide on the ESOO landing page to allow users to know what is released along with the report

Organisation(s)	Comment	AEMO response
ERM Power	Include regionally-based data for temperature-sensitive load, for residential and business in information paper. In tabular or graphical form, on the basis of increase in demand (kW) per 1 deg deviation from critical temperature	This information is contained in the Forecast Accuracy Report
ERM Power	Prior to NEM and 2015 ESOO, the normal convention was forecast and actual consumption reported on 'sent out' basis, and maximum demand reported on 'as generated' basis. Since 2016, data more difficult to access and requires manipulation to achieve consistency with other real time data. Suggest reverting to 'sent out' and 'as generated' basis to provide consistency with AEMO's real time data publication.	The http://forecasting.aemo.com.au/ portal provides auxiliary and sent out data to reconstruct 'as generated'. The use of sent-out forecasts is intended to reduce confusion and increase accuracy by making the auxiliary loads more explicit components in the forecasts, particularly relevant when the future generation mix may have materially different auxiliary loads. AEMO will consider publishing both measurements in future forecasts to reduce potential misinterpretation.
Origin	Can AEMO provide stakeholders with the breakdown of heating, cooling and baseload energy consumption on the dynamic interface?	AEMO will review if this information can be added to the interface or whether it is best served in a different document.

Table 15 Report content

Organisation(s)	Comment	AEMO response
Engie	Include a list of abbreviations	Methodology Paper now contains a list of abbreviations
Engie	Include references for recent local studies and projects, and make these studies available on the AEMO website.	AEMO's reports reference all studies, data and articles that have influenced the forecasting methods.
AEC	Provide a high-level architecture of all related forecasting functions incl. a map showing where details of each related forecasting functions are documented.	The scope of this document is limited to those forecast approaches used to produce medium to long term forecasts used for Forecasting and Planning functions, such as ESOO and ISP. AEMO will consider how it can address potential gaps across its publications at a future date.

4. Other matters

Other matters raised in the submissions relate to accuracy and verification of results, and scenario development and assumptions (see Tables 16 and 17).

4.1 Accuracy and verification of results

AEMO publishes a Forecasting Accuracy Report (FAR) for its ESOO each year. The FAR assesses the accuracy of its electricity demand and consumption forecasts to help inform its continuous improvement program and build confidence in the forecasts produced. AEMO will consider stakeholder comments related to the accuracy and verification of results in future FAR publications. These comments are summarised in Table 16.

Table 16 Accuracy and verification

Organisation	Comment
AER	Does AEMO deem the heating/ cooling load forecasting approach successful? Is evidence of accuracy observed in backcasting?
EnergyAustralia	The 'Forecast Accuracy report' reviews performance of regional annual consumption and max demand. Attributing inaccuracies to specific underlying drivers would improve stakeholder understanding of supply-demand dynamics given aggregated nature of demand data.
EnergyAustralia	Review accuracy at input level. Eg, if a TNSP or DNSP consumption forecast has a consistent bias, then the modelling process could make some adjustments (or make a note of it).
EnergyAustralia	Forecasting accuracy should extend from actual vs latest forecast to include earlier forecasts as well (eg forecasts for 2017 created in both 2016, 2015 and 2014), so that stakeholders can understand how forecasts have changed. An assessment on what key issues have led to deviations would be advantageous.
EnergyAustralia	Paper could reflect drivers modelled in the past, and assess magnitude of impact, retrospectively.

4.2 Scenario development and assumptions

In February 2019, AEMO commenced consultation on the inputs, assumptions, and scenarios to be used for its forecasting and planning work in 2019 and beyond. This includes those to be used in forecasting for the 2019 ESOO and 2019-20 ISP. The consultation invites submissions from stakeholders by 20 March 2019. More detail is available on AEMO's website.

Table 17 Scenario development and assumptions

Organisation	Comment
ERM Power	Naming of central planning forecast referred to as 'medium', 'planning' and 'neutral' scenarios over different reporting years. Suggest clearly labelled 'planning' forecast scenario be used for all medium and long-term docs, such as MT PASA, ESOO and EAAP, to determine reliability assessment.
Engie	Scenario development process needs to capture driving forces of uncertainty and construct different futures that span the range of uncertainty. Typical driving forces include economic, environmental, technological, and regulatory (eg regulated vs market-based approaches).

Organisation	Comment
Engie	Within each scenario, variables need to be internally consistent, for e.g. new connections will be different in high than low economic activity scenarios
Engie	Range of scenarios need to cover climate change policy uncertainty, from strong to no new action beyond what is currently being implemented.
Engie	Current three scenarios of most likely, high and low limit thinking. Scenarios implemented by Shell would be most appropriate for AEMO demand forecasting.
Engie	Electricity prices are highly correlated with aluminium prices. International climate change policy settings (ie coordinated action, or individual action which reduces the competitive price of electricity and shifts smelting overseas) needs to be factored when developing scenarios of future electricity demand.
Engie	Current approach of using HIA housing start projections won't work in all scenarios and fails to capture discontinuities due to regulatory and economic changes. Individual forecasts must be developed for each scenario to ensure internal consistency.

5. Final determination

In consideration of the matters raised in the submissions, AEMO's final determination is the Electricity Demand Forecasting Methodology Paper in the form published on the AEMO website[4].

[4] Available at: http://aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/NEM_ESOO/2018/Electricity-Demand-Forecasting-Methodology-Information-Paper.pdf (Accessed 28 February 2019)