AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

# WEM Demand Forecasting Methodology

**October 2018**

Issues Paper

# Important notice

## PURPOSE

The purpose of this publication is to consult on the proposed scenarios, data sources and methodologies for forecasting annual consumption and peak demand in the Wholesale Electricity Market (WEM) for use in the WEM Electricity Statement of Opportunities (ESOO).

AEMO publishes the WEM ESOO under clause 4.5.11 of the Wholesale Electricity Market Rules.

This publication has been prepared by AEMO using information available at 16 October 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** | 26/10/2018 | |

# Executive summary

The publication of this Issues Paper commences AEMO's consultation on the proposed scenarios, data sources and methodologies for forecasting annual consumption and peak demand in the Wholesale Electricity Market (WEM).

AEMO has historically relied on consultants to provide demand forecasts for the WEM for use in the WEM Electricity Statement of Opportunities (ESOO). To improve consistency with AEMO's forecasts for other regions in Australia – and to leverage the forecasting system AEMO has developed to provide detailed forecasts for these – AEMO is working towards producing the forecasts for the WEM inhouse in 2019[1].

Given the importance of the forecasts in determining the amount of reserve capacity procured through the Reserve Capacity Mechanism, AEMO wants to engage with all relevant stakeholders, to ensure the outlined forecasting approach, methods and assumptions meet stakeholder expectations.

This will ensure AEMO can deliver the best possible forecasts for the WEM and present both forecast and underlying assumptions in a way that is transparent for stakeholders.

Stakeholders are invited to submit written responses to the questions outlined in this paper, and on other issues related to forecasting WEM demand, by 5.00 pm (Australian Western Standard time) on 22 November 2018. Submissions should be sent by email to energy.forecasting@aemo.com.au.

[1] Initially, AEMO will produce the forecasts for the 2019 WEM ESOO in parallel with consultants. After this AEMO intends to produce these forecasts inhouse.

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# 1. Stakeholder consultation process

AEMO is consulting on its proposed scenarios, data sources and methodologies for forecasting annual consumption and peak demand in the Wholesale Electricity Market (WEM) in Western Australia.

AEMO's indicative timeline for this consultation is outlined below. Dates may be adjusted depending on the number and complexity of issues raised in submissions and any meetings with stakeholders.

| Deliverable | Indicative date |
|---|---|
| Issues Paper published | Friday 26 October 2018 |
| Industry workshop | Friday 9 November 2018 |
| Submissions due on Issues Paper | Thursday 22 November 2018 |
| Consultation response published | Thursday 6 December 2018 |

The submissions will inform AEMO's approach to produce electricity demand forecasts for the 2019 WEM Electricity Statement of Opportunities (ESOO). These forecasts will be produced in parallel with a consultant's forecasts for validation. Following the 2019 forecasts, additional stakeholder engagement will be undertaken to obtain feedback about AEMO's forecasts, which will be incorporated into the approach used in 2020.

# 2. Background

## 2.1 Context for this consultation

Accurate forecasts are important for both operational decisions and longer term strategic investments, but have become increasingly challenging in light of the rapid changes in how electricity is consumed, generated and potentially stored.

One of AEMO's strategic objectives has therefore been to build an advanced forecasting toolset and cloud analytics platform that uses a hybrid top-down and bottom-up approach to forecast demand. The top-down approach helps to capture historical trends, whereas the bottom-up approach helps when historical trends may no longer be reflective of future demands due to rapid changes to the power system and consumer behaviour.

Following the completion and successful use of this new forecasting system to forecast demand in the National Electricity Market (NEM)[2], AEMO intends to start using this approach to forecast electricity demand in the WEM, to improve:

[2] First use was for the 2018 NEM Electricity Statement of Opportunities. See https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/NEM-Electricity-Statement-of-Opportunities.

- Consistency with forecasts for the NEM: by using consistent scenarios, assumptions and methods, forecast levels and trends across Australia's different states and territories will be directly comparable.
- Quality of forecasts: leveraging the forecasting system, knowledge and experience used to forecast demand in the NEM.

While the WEM forecasting approach will to a large extent build on existing methods and key assumptions, AEMO wants to ensure it:

- Captures any particular aspects where forecasting electricity consumption and peak demand in the WEM may differ from the rest of Australia.
- Meet the needs of Western Australian stakeholders.

The purpose of this consultation is therefore to ensure the proposed forecasting approach is fit-for-purpose and/or identify any areas where an alternative approach would be more appropriate for the WEM.

## 2.2 AEMO's forecasting objectives

AEMO is committed to producing quality forecasts that support informed decision-making.

For decision-makers to act on our forecasts, the forecasts must be credible and dependable. To achieve this, AEMO's forecasting team has three main objectives:

- Transparency – to ensure our inputs and forecast methodologies are well understood.
- Accountability – to measure forecasting performance, refine and improve where issues are detected.
- Accuracy – to adopt best-practice methodologies and monitor lead indicators of change.

We continually seek to improve our forecasts and rely heavily on industry expertise, insights, and critique to help address the challenges of forecasting in a rapidly-changing energy industry.

## 2.3 WEM Rules requirements

Under the Wholesale Electricity Market Rules (the WEM Rules)[3], the Long Term Projected Assessment of System Adequacy (PASA) Study for the WEM ESOO must take into account (among other things) different demand growth scenarios, including peak and annual energy requirements, and expected Demand Side Management capabilities.

The WEM Rules further specify the following scenarios[4]:

i. median peak demand assuming low demand growth;

ii. one in ten year peak demand assuming low demand growth;

iii. median peak demand assuming expected demand growth;

iv. one in ten year peak demand assuming expected demand growth;

v. median peak demand assuming high demand growth;

vi. one in ten year peak demand assuming high demand growth,

where the low, expected, and high demand growth cases reflect demand changes stemming from different levels of economic growth.

The WEM Rules require the demand growth scenarios to be temperature-adjusted to produce the one in ten year peak demand cases. The one in ten year peak demand cases are also referred to as 10% Probability of Exceedance (POE) forecasts, and the median (one in two year) peak demand forecasts are 50% POE forecasts.

[3] WEM Rules, clause 4.5.2.

[4] WEM Rules, clause 4.5.10.

# 3. Proposed electricity demand forecasting approach for the WEM

The proposed forecasting approach, as outlined in this section, should be seen in the context of the requirements above. AEMO seeks feedback (see Section 4) on whether the approach will satisfy these requirements specifically and industry expectations in general.

## 3.1 Proposed scenarios of use in 2019 WEM ESOO

AEMO uses scenarios for a range of purposes and publications. To ensure key messages are aligned, AEMO uses a common set of scenarios, with use of additional sensitivities when appropriate for specific publications.

According to the WEM Rules quoted above, the Long Term PASA for the WEM ESOO must take different demand growth scenarios into account, reflecting demand changes stemming from different levels of economic growth. A Market Procedure[5] states that AEMO may use any variables for the efficient forecasting of electricity maximum demand and operational consumption. These variables include, but are not limited to:

a) air-conditioning penetration and saturation rates;

b) rooftop photovoltaic (PV) installation and capacity factor rates;

c) battery storage installation rates;

d) electric vehicle growth rates;

e) forecasts of building approvals, new home starts etc; and

f) any other information, data, condition or constraint deemed necessary or appropriate in order to produce forecasts in line with industry best practices.

These are all factors AEMO considers in the forecasting models proposed for use in the WEM ESOO.

Draft scenarios for the 2019 publications are under development. These form an envelope of outcomes with different changes to grid-connected generation and transmission needs. The draft high-level scenario assumptions are listed in Table 1 below.

The scenarios will give the expected (Neutral), low (Slow change), and high (Fast change) demand variations required.

AEMO would generally expect a higher uptake of rooftop PV in a high economic growth scenario (which will then lower consumption from the grid), and similarly expect a lower uptake during a low economic growth scenario, as the ability to invest in installations will differ. Other factors, such as the costs of installation, may pull in the other direction. But as a reasonable case, which maintains a large spread between the scenario outcomes, AEMO has chosen to use the Neutral rooftop PV uptake projection across all three scenarios. As an example, this assumes that a similar level of uptake may be observed under expected economic growth and cost reductions as under lower economic growth but with faster cost reductions.

[5] Market Procedure: Undertaking the Long Term PASA and Conducting a Review of the Planning Criterion, clause 2.7.4.

Table 1 **Draft high-level scenario specifications**

| Scenarios | Neutral | Slow change | Fast change |
|---|---|---|---|
| **Demand settings** | | | |
| Economic growth | Neutral | Weak | Strong |
| Population outlook | Neutral | Weak | Strong |
| Rooftop PV uptake | Neutral | Neutral | Neutral |
| Battery storage uptake | Neutral | Neutral | Neutral |
| Electric vehicle uptake | Neutral | Weak | Strong |
| **Policy settings** | | | |
| Emissions reduction trajectory | 28% 2005-2030 | 28% 2005-2030 | 52% 2005-2030 |
| | 70% 2016-2050 | 70% 2016-2050 | 90% 2016-2050 |
| Federal Large-scale Renewable Energy Target (LRET) | Yes | Yes | Yes |
| Energy efficiency improvements | Neutral | Weak | Strong |
| **Supply settings** | | | |
| Variable renewable energy (wind and utility-scale PV) cost reductions | Neutral | Slow | Neutral |
| Storage (pumped hydro, battery, and solar) cost reductions | Neutral | Neutral | Fast |

## 3.2 Key data sources for the WEM demand forecasts

The following are the proposed key data sources for producing the WEM demand forecasts.

### Weather/climate data

Weather and climate data is used to calculate the impact of weather outcomes on consumption. In particular:

1. Temperature (impact on cooling and heating load).
2. Solar insolation (impact on rooftop PV generation offsetting consumption supplied from the grid).

AEMO uses a range of weather services, typically the Bureau of Meteorology (BOM), for temperature, and the Commonwealth Scientific and Industrial Research Organisation (CSIRO)/BOM for climate projections[6] that are used to assess how temperature distributions change over time in response to climate change.

BOM is also used as source for solar insolation data, but AEMO is continuously looking for other options to supplement data available from BOM.

### Demographics

The number of households will affect forecast consumption. AEMO has a model (see Section 3.3) that estimates the future number of households. This is based on three key data sources:

1. Forecast housing completion – this forecast is provided to AEMO by the Housing Industry Association (HIA) and is the key driver in the early years.

[6] CSIRO and BOM: Climate Change in Australia website. See http://www.climatechangeinaustralia.gov.au.

2. Population projections from the Australian Bureau of Statistics (ABS) or the WA Department of Planning, Lands and Heritage[7] are the key driver for longer-term growth.
3. The current starting point is calibrated against the existing number of electricity connections (provided by Synergy).

### Historical demand

To build demand forecast models, historical data series of demand (predicted value) and the key drivers (predictors) are both needed. For historical demand, AEMO has data for all grid-connected generators, which can be used to calculate operational consumption and demand (which is the demand met by these generators).

Additional meter data for contestable customers is also available to AEMO, allowing potentially some disaggregation of business consumption. AEMO will investigate whether, over time, we can obtain further meter data for a finer split of consumption into segments.

### Economic trends

Business sector consumption (both commercial and industrial) is driven by a range of economic factors:

1. Gross State Product (GSP) and State Final Demand (SFD).
2. Household Disposable Income (HDI).
3. Exchange rate.
4. Commodity prices and forecast exports.

AEMO generally obtains this information (historical and forecast values) from economic consultancies. The actual use of the data series for the WEM demand forecasts will depend on which data gives the best model fit.

### Retail price

The retail price is not expected to vary significantly over the forecast. AEMO will, however, monitor the historical and expected trends based on data from the Public Utilities Office and the Western Australian Budget Papers, and will consider it as a candidate driver to the consumption model.

### Behind-the-meter technologies

Consumption and peak demand is affected by the uptake and use of a number of 'behind-the-meter' technologies. In particular:

1. Rooftop PV.
2. Battery storage.
3. Electric vehicles.
4. Energy efficiency.
5. Air conditioners.

For our forecasts, AEMO generally relies on consultant estimates for uptake and use of these technologies. The exception is air-conditioners, where AEMO generally uses the appliance database used for the Residential Baseline Study[8] to assess future trends of air-conditioning and any other household appliances, such as heaters.

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[7] WA Department of Planning, Lands and Heritage. WA Tomorrow (2015). See https://www.planning.wa.gov.au/publications/6194.aspx.

[8] Commonwealth Department of Industry and Science. Residential Baseline Study for Australia 2000 – 2030 (August 2015). See http://www.energyrating.gov.au/document/report-residential-baseline-study-australia-2000-2030.

## 3.3 Submodels

A number of important submodels are used in AEMO's forecasting process. These are explained in AEMO's 2018 NEM ESOO Demand Forecasting Methodology Information Paper[9]:

- Temperature and climate – explaining temperature impact on heating and cooling demand, and how climate change will affect this. See Appendix A2 of the Methodology Information Paper.
- Connections forecast – forecast growth in number of electricity connections (households). See Appendix A5 of the Methodology Information Paper.
- Rooftop PV generation – calculation of expected rooftop PV generation for a given installed capacity. See Appendix A3 of the Methodology Information Paper.

## 3.4 Approach for operational consumption forecast

AEMO's operational consumption forecast is split into a base year (short-term) model and a long-term growth model. The overall approach is explained in Section 4 of AEMO's 2018 NEM ESOO Demand Forecasting Methodology Information Paper[10]. The following discussion focuses on where the proposed WEM forecast approach differs from the NEM approach.

At a minimum, AEMO will use a split of consumption into mass market and large industrial (block load) consumption. This is consistent with historical forecasts for the WEM. To the extent that meter data allows AEMO to disaggregate the mass market segment further into subsectors (such as residential), AEMO will do this.

### 3.4.1 Base year consumption forecast

A high-level overview of the base year forecast approach is shown in Figure 1 below.

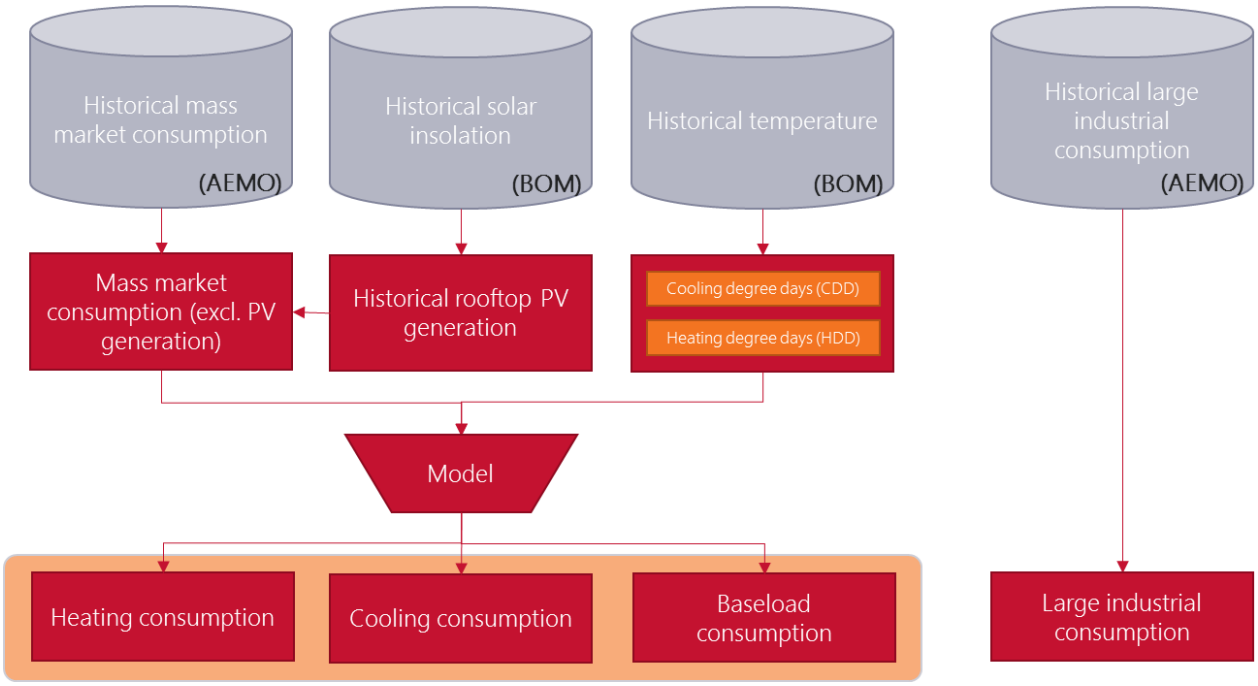
Two key steps to note are:

- Historical consumption is adjusted back to what it would have been if no rooftop PV had been generating, representing the true customer demand.
- This demand is split into heating, cooling, and baseload (non-temperature-sensitive) consumption.

[9] AEMO. Demand Forecasting Methodology Information Paper (September 2018). See https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/NEM_ESOO/2018/2018-Demand-Forecasting-Methodology-Information-Paper.pdf.

[10] Ibid.

**Figure 1 Base year model for operational consumption**



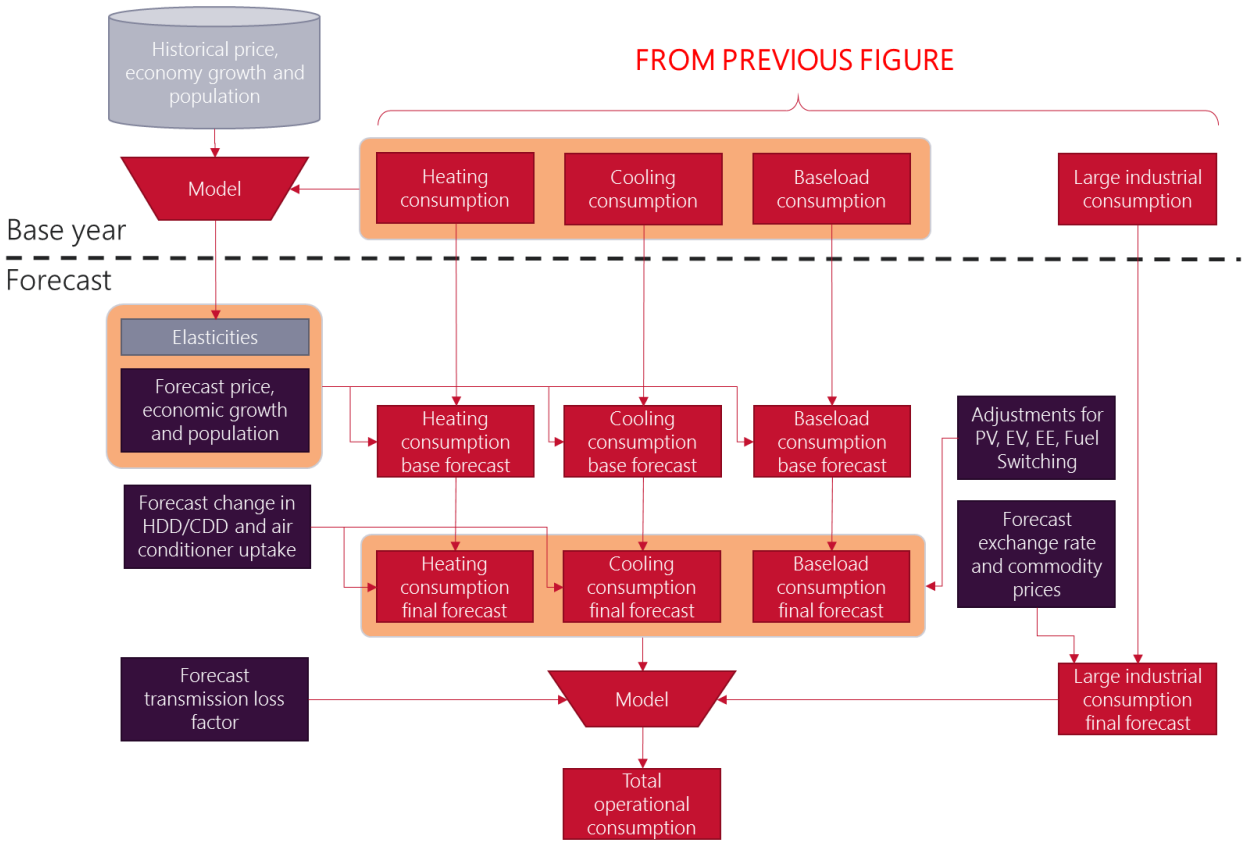

### 3.4.2 Consumption growth forecast

Based on the base year consumption forecast, which establishes historical and current year consumption by heating, cooling, and baseload, an econometric model will establish key relationship with growth drivers, such as economic growth.

Forecast consumption will be grown separately for:

- Mass market, with heating, cooling, and baseload consumption grown independently based on:
  - Forecast economic growth, number of electricity connections, and potential retail price.
  - Forecast demand for heating (HDD) and cooling (CDD), taking into account climate change.
  - Forecast growth in air-conditioner penetration.
  - Forecast uptake of rooftop PV and the generation from the installed capacity.
  - Forecast uptake of electric vehicles (EV).
  - Forecast energy efficiency (EE) measures and impact of gas to electric fuel switching.
- The large industrial forecast is grown based on forecast exchange rate and commodity prices (translated into forecast export by commodity) verified with information from the industries themselves.

**Figure 2 Growth model for operational consumption**




## 3.5 Approach for maximum demand forecast

Similar to AEMO's operational consumption forecast, the peak demand forecasts will be split into a base year (short-term) model and a long-term growth model. The overall approach is explained in Section 5 of AEMO's 2018 NEM ESOO Demand Forecasting Methodology Information Paper[11].

### 3.5.1 Base year model

Working on half-hourly data, the data preparation, cleaning, and outlier detection and removal is important.

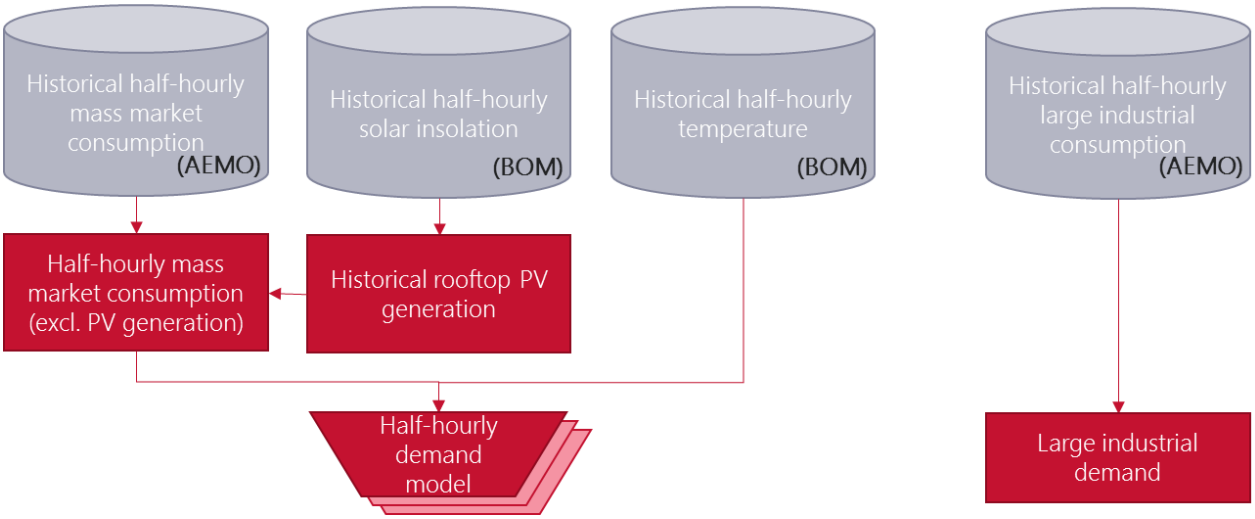
Once data is prepared, actual historical underlying demand by half-hour is calculated adding back on estimated demand met by rooftop PV generation that period.

A short-term model is then built for each half-hour of the day and exploratory data analysis used to find the key variables that drive demand that period. This includes the temperature that period's impact on cooling or heating demand and the impact of longer-term heat waves/cold snaps on demand. Calendar effects (weekday/weekend, public holidays) will also be included. The best models will be selected based on a range of criteria.

Large industrial loads with flat demand will be kept separate, as these do not have the same drivers (such as temperature) for their operation.

[11] AEMO. Demand Forecasting Methodology Information Paper (September 2018). See https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/NEM_ESOO/2018/2018-Demand-Forecasting-Methodology-Information-Paper.pdf.

**Figure 3 Base year model for peak demand**




### 3.5.2 Peak demand growth forecast

Based on historical weather data, 1,000 weather years are created, each representing weather outcomes – including solar insolation – for every 17,520 half-hour period in the year.

Based on the half-hourly models developed for the base year, half-hourly demand traces are estimated for all 1,000 simulated years.

The forecast process grows half-hourly demand using an index from the forecast consumption growth by heating/cooling/baseload, reflecting the growth of economic conditions such as price and GSP, demographic drivers such as growth in residential connections, and technological conditions such as energy efficiency.

In addition, the forecast impact of electric vehicle uptake and charging behaviour is applied.

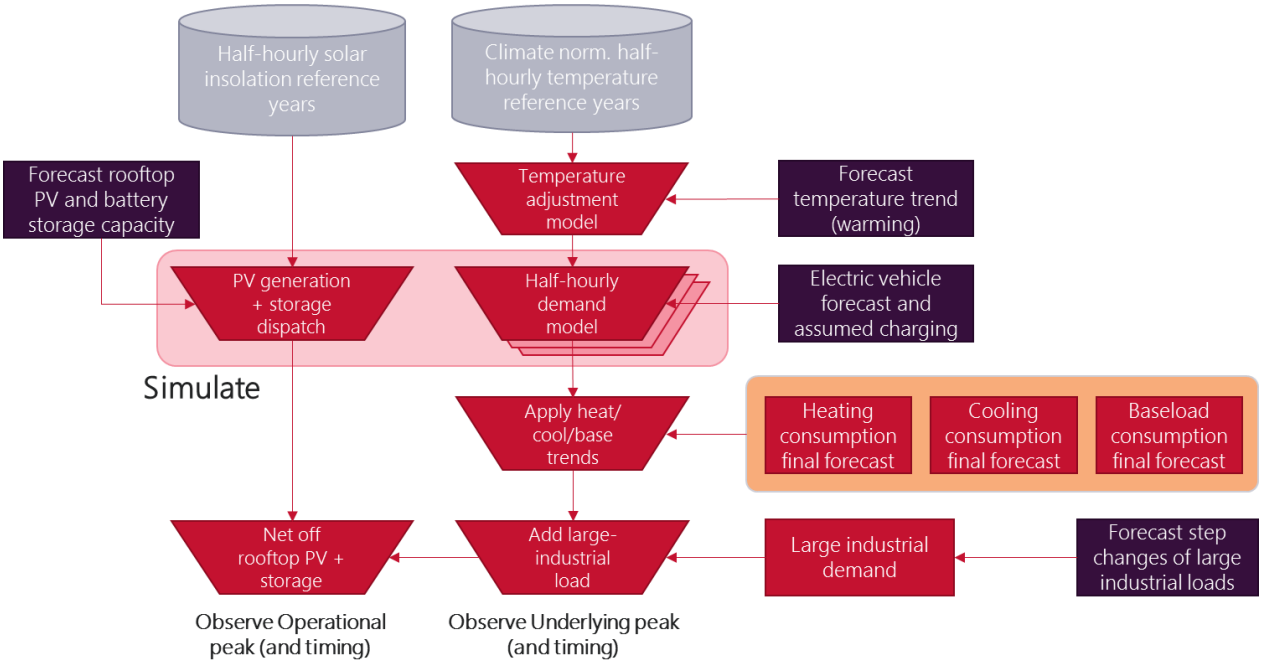
The forecast year-on-year change is applied to each of the half-hours for each simulation, and to each forecast year. This gives the customer (underlying) demand.

The process then calculates operational demand solar by subtracting rooftop PV generation and applying battery storage charging/discharging pattern, based on advice from the consultant.

This process yields minimum/maximum demand values at each half-hour over a simulated year. This represents the minimum/maximum half-hourly prediction of the 17,520 half-hourly predictions in a given year, for each year in the forecast horizon. After simulating 1,000 times there will be 1,000 values for each forecast year, for each season, for each scenario.

From the 1,000 simulated minima/maxima, AEMO extracts the 50% and 10% POEs as well as the characteristics at times of the minimum/maximum (such as weather conditions and calendar positioning at the time of minimum/maximum).

**Figure 4 Growth model for peak demand**




### 3.5.3 Individual Reserve Capacity Requirement response and peak demand

The cost allocation of the capacity market auction[12] may cause large industrial customers (typically) to seek to reduce their consumption in half-hours that they estimate may be among the top 12 combined peaks for the WEM, which are used to determine their Individual Reserve Capacity Requirement (IRCR). AEMO will monitor how the estimated IRCR response looks on a year-by-year basis, but as long as the amount is broadly the same, the peak forecast will not be adjusted, as the historical response is reflected in the historical demand series used for the forecast, and will be implicitly reflected as long as they are of a similar magnitude year-on-year.

## 3.6 Assessing forecast accuracy

Each year, AEMO assesses the quality of the demand forecast that was used in the previous ESOO for the NEM. These are published by the Australian Energy Market Commission (AEMC)[13].

For the WEM demand forecasts, AEMO proposes to use a similar framework to monitor performance of our forecasts.

This reporting tracks operational consumption and key component forecasts, explaining differences (where possible) based on variations in key input data, such as weather and PV generation, and helps to identify areas for future forecasting improvement.

Measuring the accuracy of peak demand forecast is more difficult, given the probabilistic nature of these forecasts that are highly dependent on weather. AEMO is currently consulting with industry on methods to better assess the accuracy of probabilistic peak demand forecasts. The outcome of this work will lead to improved assessments of forecast accuracy in 2019.

[12] See https://www.aemo.com.au/Electricity/Wholesale-Electricity-Market-WEM/Reserve-capacity-mechanism/Individual-reserve-capacity-requirement-information.

[13] Reports are available at https://www.aemc.gov.au/our-work/developing-electricity-guidelines-and-standards.

# 4. Feedback

AEMO invites stakeholders to provide feedback on whether the outlined scenarios, data sources and methodologies are appropriate for producing demand forecasts for the WEM and meet industry expectations in general. The questions below can be used as a guide.

Stakeholders are invited to submit written responses on the questions below and other issues related to forecasting WEM demand by 5.00 pm (Australian Western Standard time) on 22 November 2018. Submissions should be sent by email to energy.forecasting@aemo.com.au.

**Questions for consultation**

**1. Forecast use**

Use of ESOO forecast

1.1 How is the ESOO demand forecast used in your business (if at all)?

Scenarios

1.2 Are the proposed scenarios fit-for-purpose for use in the WEM ESOO?

1.3 To supplement the scenarios, are there any sensitivities relevant to consider for WA?

**2. Transparency**

2.1 Is the level of detail provided in the referred ESOO forecasting methodology report sufficient to allow you to constructively critique and provide feedback on the appropriateness of the methodology? If not, what additional information/explanations are required?

**3. Accountability**

3.1 AEMO proposes to assess forecast accuracy at least annually to inform internal continuous improvement processes and to build stakeholder confidence in the forecasts. Is AEMO's proposal for assessing forecast accuracy appropriate?

**4. Accuracy**

Data sources

4.1 Are there any data quality or data latency issues with the proposed data sources?

4.2 Are there any additional data sources that should be considered?

Annual energy consumption

4.3 Is the approach for forecasting energy consumption appropriate?

Peak (maximum) demand forecast

4.4 Is the outlined approach for forecasting maximum demand appropriate?

4.5 Is it appropriate to assume the impact of IRCR response is captured directly in the peak demand forecast without any special adjustments being made?

New technologies

4.6 AEMO directly accounts for rooftop PV, battery storage, and electric vehicles. Are there any other new technologies AEMO should start to consider?