APPENDIX B - AUGEX UNCERTAINTY RISK APPRAISAL (AURA) MODEL

MODEL METHODOLOGY

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# 1 Introduction

## 1.1 Overview

Traditional approaches to evaluation of augex projects have tended to bias capital intensive network solutions due to a failure to fully capture the benefits of demand side and/or modular network solutions.

Demand side and modular network side solutions (such as network batteries) have two potential types of value:

- Deferral of capital intensive network solutions
- Options value (whereby the modular option can be ramped up or down as demand changes, reducing the potential for over-expenditure compared to long life fixed assets, the higher the demand uncertainty, the greater the options value)

CutlerMerz Augex Uncertainty Risk Appraisal (AURA) model considers a range of demand side and network side solutions and produces a net present value to enable decision making with respect to augmentation expenditure incorporating both the deferral and options value of non-traditional solutions.

The tool requires the input of a probabilistic demand forecast (in the form of upper and lower bounds) and determines, via Monte Carlo analysis, which augex solution is most likely to result in the highest NPV across the full range of demand forecasts. The tool allows the network planner to identify the likelihood that the traditional network solution will result in the lowest Net Present Cost.

## 1.2 Purpose of this Document

This document provides the assumptions and logic behind CutlerMerz's AURA model for Evoenergy and the model's application to Evoenergy's Project Justification Reports.

# 2 Model Logic

## 2.1 Structure Overview

The AURA model utilises a dynamic build response to peak demand changes over time and selects the most cost effective option for the network operator given uncertain peak demand forecasts.

The main steps in the model are:

- Each year generate a feasible level of change in peak demand based on an assumed uniform probability distribution function between an upper bound demand forecast and lower bound demand forecast
- Revise the demand forecast to reflect the realised peak demand for the current year
- If peak demand is above the existing asset's firm rating, invest in network and/or non-network augmentation options that can satisfy demand (using the revised demand forecast) for the design life of the option
- Repeat the build decision for each year from 2020 through to 2039
- Calculate the net present cost of each potential combination of network and non-network options over the period between 2020 and 2039
- Repeat the above steps 50 times (Monte Carlo simulation) and use the average cost across all 50 simulations to select the preferred option

## 2.2 Demand Forecast

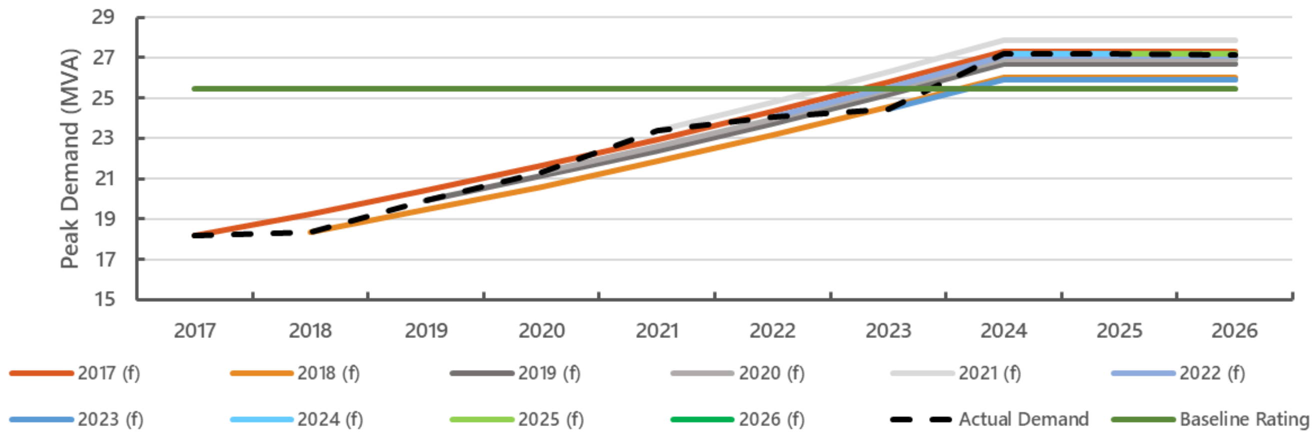
To stress test the different options available to the network, the AURA model introduces forecast uncertainty by applying random variation to peak demand growth.

A base peak demand forecast is created. Usually this forecast is based on new spot loads that are expected to be added to the network. Forecasts beyond these spot loads may be a constant growth rate to reach a defined future load target or zero for smaller feeder projects that are only focused on meeting shorter term needs.

From the base forecast, an upper and lower bound is selected (default 0.9x and 1.1x base). The model uses a uniform probability distribution function to select a growth rate for each year that is within the upper and lower bounds.

Figure 1 provides an example of how the design forecast changes over time in response to observed levels of peak demand growth. When peak demand growth is lower (higher) than the previous year's forecast, such as in 2018 when demand was forecast to rise to 19MVA but the actual result was 18MVA, the forecast curve is pulled downwards (upwards) for all future periods.

**Figure 1 – Example of Shifting Demand Forecasts**




## 2.3 Augmentation Options

When peak demand exceeds the firm rating the model will immediately invest in augmentation to ensure that sufficient firm capacity is maintained. The model calculates a build profile for different combinations of network and non-network options.

The below sections discuss the different options available to the network.

### 2.3.1 Demand Management

Demand management is implemented in the model as a one-off expense that permanently reduces peak demand by a set value. If the firm rating is exceeded, the model will select as many demand management options as necessary to remain under the firm rating for the current year and the following year. The model prioritises demand management options from the least expensive to most expensive.

As the peak reduction capacity of all the available demand management options is limited, demand management may not be able to reduce peak demand below the firm rating.

### 2.3.2 Network Battery

The network battery option allows the network operator to install a battery to increase the firm rating of a network area. The battery is intended as a temporary augmentation that allows the network operator to maintain firm capacity where either the demand forecast is expected to exceed the firm rating before falling (a temporary exceedance) or to defer the timing of a permanent network augmentation.

Network owned batteries are large, with an assumed module size of 2MWh and an assumed lifetime of 10 years. The batteries are mobile so they can be redeployed to other points on the network as needed. This allows the for the cost of a battery to be recovered over multiple projects (i.e. network needs) rather than on the first project that it is deployed on.

The model uses a leasing framework to allocate the cost of a battery to a single project. For each year, the battery cost is calculated as:

$$Annual\ Cost = \frac{Purchase\ Price_{\$/kWh} * Size_{kWh} * WACC}{1-(1+WACC)^{-Lifetime}} + Operating\ Costs$$

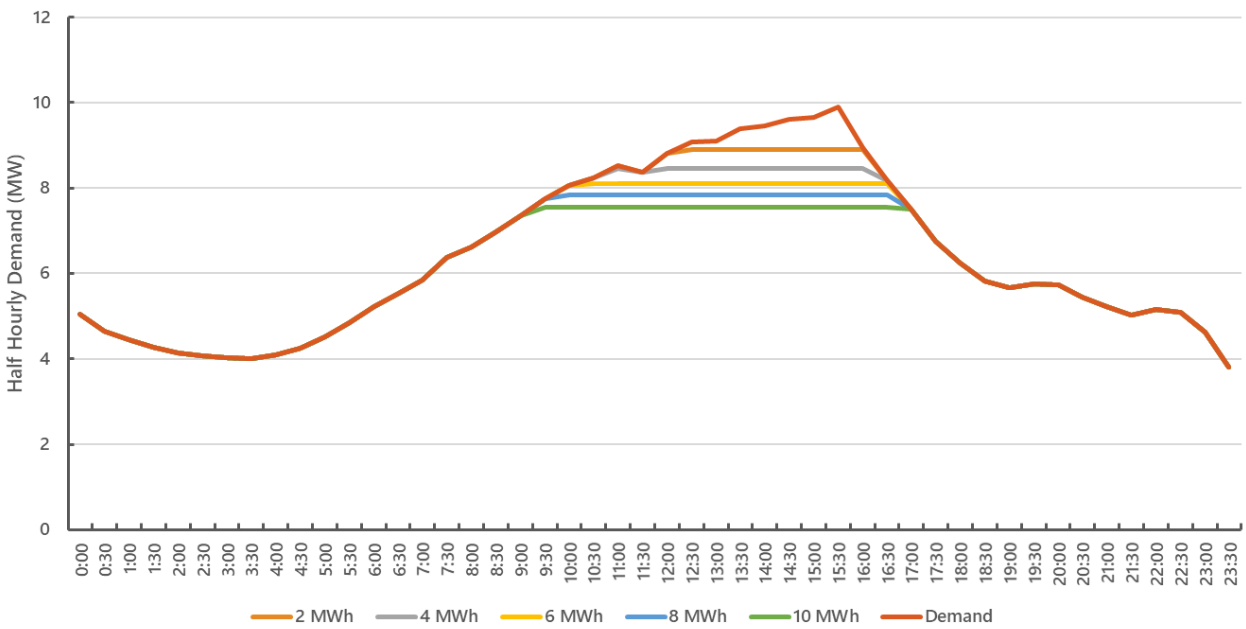
The cost calculation for the battery implies that the network operator has immediately available redeployment options for batteries that are used, or can lease the batteries from a third party that is willing to take on the risk of finding alternative uses for the batteries. The risk would then be factored into the lease price. The model allows the total number of batteries to be constrained to reflect the difficulty of Evoenergy being able to find alternative uses for a large number of batteries. The default value for this is five batteries.

**Battery Effectiveness**

In general, as peak demand grows, the volume of energy above the firm rating rises faster than the level of peak demand and peak events become 'wider' (firm rating is exceeded for more hours). Batteries have a limited discharge capacity, so are therefore constrained by the volume of energy that must be served rather than the size of the peak. The battery's effectiveness in reducing peak demand therefore reduces as the total required peak reduction required increases.[1]

This can be seen in the example in Figure 2 below. Each successive 2MWh increase in total battery size reduces the peak by a lower amount. The first 2MWh achieves a 1.0MW reduction in peak demand, whereas the change from 8MWh to 10MWh only reduces peak demand by 0.3MW.

**Figure 2 – Example Peak Reduction by Batteries by Capacity**




By default, the first battery reduces peak demand by 2MVA/2MWh installed. Each additional battery produces 16.7% less peak reduction than the previous battery per MWh (and the cost of peak reduction rises by 20% for each additional 2MVA required).

### 2.3.3 Network Options

The AURA model takes a dynamic approach to the timing of network augmentation options. When the firm rating is exceeded, the first stage of a network option is installed. If the first stage does not provide sufficient capacity to meet forecast demand over the design life of the network option, additional stages will be built immediately. Otherwise, additional stages will be built if and when the firm is exceeded.

Where an option has multiple stages, the stages are always built in order. The model also allows network option stages to be unavailable until a given year. This can be used to prevent immediate building of complicated projects that do not yet have development approval and will require lead times for construction.

The model does not include construction time. As soon as a breach of the firm rating occurs the capital expenditure is recorded and the new asset becomes available immediately.

[1] There is an exception in an extreme case where the the peak is flat with a sharp drop off either side of the peak period.

It is necessary that the network options available to the network can provide sufficient capacity to meet the upper bound of the forecast. Any option that cannot satisfy peak demand for all simulations is excluded from being selected as the preferred option by the model.

### 2.3.4 Mixed Options (Delay network option with DM/Battery)

The model introduces the option to delay an expensive network build by investing in demand management and network owned batteries. Delaying is economic when the financing cost of the capital invested in a network upgrade (*Capital Expenditure * WACC)* is greater than the cost of investment in non-network options. This is likely to occur when peak demand is only slightly above the firm rating and the required network upgrade is very large and may add unnecessary amounts of capacity that will not be utilised for years to come.

The model always implements a non-network option to delay a network augmentation for one year. Any additional years of deferral will only be invested in if the model determines that it is economic to do so. This ensures that if deferral is not economic for even one year this will be reflected in a higher net present cost than the best network only option.

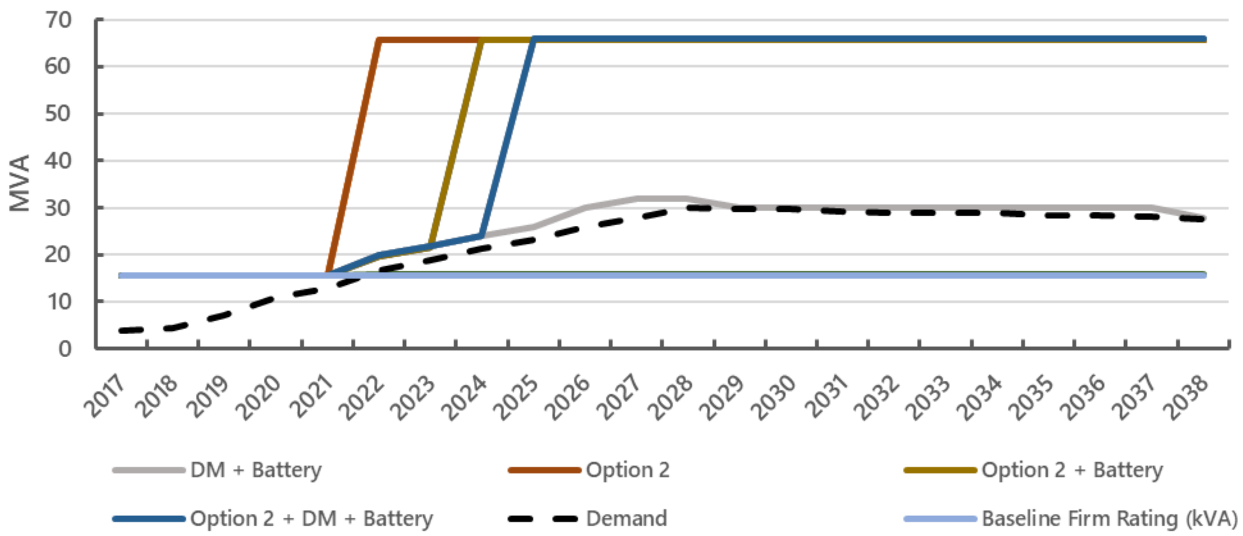
The model tests two different mixed combinations for each network option. The first assumes only network owned batteries can be used to delay investment and the second allows both demand management and network owned batteries. The reason for this approach is because the model always selects all demand management options before batteries[2]. If demand management is more expensive than batteries this would result in a sub-optimal outcome.

In the model's reporting, only the best combination of network and non-network options is presented in detail.

### 2.3.5 Augmentation Options Example

Figure 3 below shows an example of the build profiles for a single simulation. In 2022 peak demand exceeds the firm rating of the asset. If the network option is selected the firm rating immediately increases to a higher level (brown line in 2022), which in this case far exceeds the forecast demand. When non-network options are allowed, the firm rating is able to track demand growth until a future point, at which time a network option is implemented (2024 for the gold and 2025 for the blue line). If only non-network options are used, the firm rating can track demand growth downwards if demand falls in the future by redeploying batteries, which can be seen in 2029 (grey line).

**Figure 3 – Network Capacity Under Different Augmentation Options**




[2] The model can only invest in network batteries after all demand management options are exhausted, due to technical limitations the model is not able to select the cheapest demand management options and then battery, leaving the most expensive demand management option unused.

## 2.4 Net Present Cost

The model selects the best augmentation option by minimising the net present cost (NPC). The NPC is calculated over two periods, the next regulatory period (FY2020-FY2024) and for the next 20 years (FY2020-FY2039). The discount rate used in both calculations is the assumed WACC.

The simulation NPC is the average NPC for a given combination over all 50 simulations. If there is a single simulation where the combination did not provide sufficient firm capacity it is excluded from selection as the preferred investment. In general, only demand management can fail to meet this requirement. If the forecast peak demand is greater than the capacity being provided by a network option the planning for this option should be revisited (outside of the modelling process).

## 2.5 Net Present Benefit

The benefit of a network augmentation is the reduced risk of being unable to serve energy to end-users. Under a do nothing scenario no augmentations are done to the network. This results in the firm rating, and then the emergency rating, of the network being exceeded.

To calculate this benefit a value is placed on the quantity of energy that is unserved or at risk of being unserved if no augmentation occurs. The net present benefit can be compared to the net present cost of the selected augmentation option to calculate the net present value of the augmentation. The net present benefit is made up of the three components described below.

**Energy above the firm rating**

Evoenergy's HV network operates in a n-1 configuration. Under normal circumstances, energy above the firm rating can be supplied and there is no cost. However, there is a small probability of a transformer (default: 3%) or feeder (default: 3%) failure, in which case the thermal rating of the network will fall to the firm rating and any demand above the firm rating will need to be shed.

A failure is expected to be resolved within 8 hours, therefore the probability of failure, in a network area where there are two points of failure, in any given hour is:

$$Probability\ of\ Failure = (2 * 3\%) * \frac{8}{365 * 24} = 0.005\%$$

The volume of energy above the firm rating is calculated using an indicative load duration curve for Evoenergy's network. The load duration curve is scaled to match the peak demand of the network area and can be used to calculate the volume of energy above the firm rating.

The probability of a failure occurring at any given point in time is assumed to be equal so each unit of energy above the firm rating has the same probability of occurring at the same time as a network outage.

The expected value of this component of the value of risk is:

$$Value = Annual\ Energy\ Above\ Firm * Probability\ of\ Failure * VCR$$

Due to the very low probability of failure, the value of this component is usually very small.

**Energy above the emergency rating**

To maintain the safety of the network, the model assumes no energy can be supplied above the emergency rating. The model also assumes Evoenergy has the ability to shed loads equal to demand above the emergency rating so that during events where demand is above the emergency rating, energy supplied equals the emergency rating.

The value of this component of the net present benefit is:

$$Value = Annual\ Energy\ Above\ Emergency * VCR$$

This is equivalent to the value of energy above firm with a 100% probability of failure. The cost of this component can become very large, but due to the relatively high level of the emergency rating, the cost is often zero except when forecast growth rates are very high.

**Direct financial costs**

Whereas the above components are theoretical costs based on VCR, Evoenergy also faces direct costs, in the form of litigation, reputational and other financial costs.

These are charged per event where energy is not served[3]:

- Litigation costs = $100,000 / event
- Reputational risk cost = external consultations and communications costs = $10,000 / event.
- Financial risk cost = internal investigation costs = $10,000 / event.

The total cost is $120,000 / event. The model calculates an approximation of the expected number of events each year and multiplies this by the expected cost per event.

## 2.6 Programmatic Approach

The programmatic approach is used to identify the projects that are most vulnerable to demand uncertainty. In this way, the model can be used to identify the projects that are most likely to result in expenditure that may not be required. In the programmatic approach, the model varies selected input values to achieve a reduction in the net present cost across all projects relative to the use of network options only.

The model attempts to answer the following questions:

- How much would the demand forecast need to reduce by to achieve the required capex reduction?
- How much additional penetration of DM would be required to achieve the required capex reduction?
- What would the cost of network owned storage need to be to achieve the required capex reduction?

To answer the first question the model reduces all values of the peak demand forecast by 5%, runs all projects and calculates the total net present cost of the preferred options. This adjustment only applies to the growth portion of peak demand, the existing level of demand is assumed to be unchanged. The forecast is then reduced by a further 5% and this process continues until the desired reduction in the augex program total expenditure has been achieved. In extreme cases, this may result in negative growth rates.

For the second question, the model scales up the quantity of capacity reduction available from demand management options. The model scales these up in increments of 25% of the initial value.

For the third question, the price of network owned batteries is reduced in $25/kWh increments until the required capex reduction in achieved.

In addition to the questions posed above, which are at the program level, the model also finds the point at which each individual project is able to be deferred using the same three mechanisms.

[3] Risk costs are sourced from Evoenergy

The model records the required change for each of the three options and which projects are changed to get the outcome. The three options are assessed independently so combinations of forecast reduction, demand management increase and battery price reductions are not allowed.

The results of this approach may not be achievable for some projects, such as when large demand forecast reductions are needed on projects where the forecast is made up of highly certain spot loads. The programmatic outputs are only an indication of the scenario that must be achieved for the required reduction in capex to be achieved.

# 3 Inputs

## 3.1 Business Case Inputs

**Table 1 – Model inputs**

| Model Input | Description |
|---|---|
| **Base Year** | The base year for initial values for customer load and equipment ratings |
| **Customer Load (Base Year)** | Initial customer maximum demand in kVA |
| **Continuous Rated Capacity (Current)** | Firm capacity in kVA |
| **Emergency Capacity** | Emergency capacity in kVA |
| **Outage length** | Estimated length of an average outage in hours |
| **Probability of Failure occurring above firm rating** | Probability of the network operating with a failure in any given hour. A function of outage length. |
| **% Residential** | Percentage of customer consumption due to residential |
| **% Business** | Percentage of customer consumption due to businesses |
| **Network Option Design Life** | Forecast period used when determining the sizing of a network augmentation option |
| **Network Option Opex** | Annual operating cost as a percentage of capital expenditure |
| **Network Option Capital Expenditure** | Capital expenditure by stage of project |
| **New Capacity (Firm)** | Added firm capacity by stage in kVA |
| **New Capacity (Emergency)** | Added emergency capacity by stage in kVA. By default this is set equal to new firm capacity |
| **Available Year** | The year in which a project stage becomes available. Some large projects are not available to be built immediately even if the network is in breach of the firm rating. |
| **Forecast Peak Demand Growth rate** | Expected growth in peak demand, entered as an upper and a lower bound. |
| **Demand Management Cost** | Upfront cost of each demand management option in $/kVA |
| **Demand Management Available kVA** | Available peak demand reduction available in the project area for each demand management option. |