Nuttall Consulting

Regulation and business strategy

AER augex model

Assessing the Endeavour Energy augex forecast

A report to Endeavour Energy

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Executive summary

Nuttall consulting has been engaged by Endeavour Energy (Endeavour) to undertake an assessment of its augmentation expenditure (augex) forecast. This assessment must use the predictive model the Australian Energy Regulator (AER) has indicated it will use as part of the process it will apply to assess expenditure forecasts. This model is called the AER augex model.

To prepare this model, we have used data that Endeavour will report in its Reset Regulatory Information Notices. This process has been supported by other data provided by Endeavour and other comments and advice provided during the course of various meetings with relevant Endeavour personnel.

Endeavour has requested that we assess two scenarios using the augex model[1]:

- augmentations due to organic demand growth only, which covers \$88 million[2] (22%) of Endeavour's augex forecast over the next regulatory period
- augmentations due to both organic and greenfield demand growth, which covers Endeavour's total (modellable) augex forecast of \$398 million over the next regulatory period.

The greenfield component of demand growth has been excluded from the first scenario as the augex model assesses expenditure that should be related to the existing utilisation of the network. Augmentations due to greenfield growth is consider to have a weaker relationship to the existing utilisation, and therefore, the assessment finding could be considered to be weaker.

To undertake these assessments, we have applied similar principles to those used when undertaking an assessment using the AER's repex model. In this regard, model planning parameters have been calibrated to reflect the four years of Endeavour's augex (2013/14 to 2016/17 inclusive[3]). As such, the model forecast could be consider a type of indicative intra-company (or business-as-usual) benchmark study[4].

Key assessment findings

Our assessment using the AER's augex model supports Endeavour's augex forecast.

- The model assessment provides very strong support to Endeavour's augex forecast associated with the organic demand growth only scenario. Endeavour's forecast of \$88 million for this scenario is well below the equivalent forecast produced by the model, with Endeavour's forecast at only 29% of the model's forecast of \$305 million.

[1] Note, these augex amounts exclude the component of augex that Endeavour has allocated to the "Unmodelled" category in RIN Table 2.4.6.

[2] All expenditure quoted in this report is in Real June 2019 dollars, unless stated otherwise.

[3] Note, unlike the repex model which uses a five year calibration period, a four year period is used for the augex model because of how the AER has defined the data that Endeavour should report in its Reset RIN.

[4] Note, unlike with the repex model, the AER has not published benchmark parameters that would allow an inter-company benchmark study to be produced.

- The model assessment also supports to Endeavour's augex forecast when both organic and greenfield demand growth is included. Endeavour's forecast of $398 million for this component is below the equivalent forecast produced by the model, with Endeavour's forecast at 67% of the model's forecast of $589 million.

We note that Endeavour is forecasting a much more significant reduction in organic demand growth driven augmentation than the model, but this difference between the Endeavour forecast and the model's reduces when greenfield demand growth is allowed for. We consider two factors could be causing this change:

- Endeavour has advised that the first year of the calibration period (2013/14) will include some augmentations that would have been driven by the previous and more onerous licence conditions; this should affect the component of demand growth that strongly relates to the utilisation of the existing network.
- The greenfield demand growth component may drive augmentations that are more weakly related to utilisation than the organic component. But we would expect that there will be some variation in this strength between augmentations. Therefore, from the model's perspective, there could be a more significant component of greenfield growth that the model would see as strongly related to utilisation and so could be included with organic growth. If this component (and its augex) had been moved into the organic growth scenario then this would most likely reduce the discrepancy between the scenarios.

Finally, it is also worth noting that both Endeavour and the model are forecasting that augex per unit of demand growth will reduce significantly from historic levels. The total demand growth is forecast by Endeavour to increase by a factor of approximately 1.6 from historical levels (e.g. 1.7% per annum historically compared to a forecast growth rate of 2.7% per annum). The model predicts total augex only needs to increase by a factor of 1.3 due to this increase in demand growth. Endeavour on the other hand is forecasting a much more significant reduction in augex than predicted by the model, with Endeavour's forecast of total augex reducing by 10% compared to historical levels.

In conclusion, we consider this assessment to be a reasonable top-down guide to Endeavour's augmentation needs, of which the results provide a form of supporting independent regulatory challenge to Endeavour's own augex forecast. However, it is important to stress that the assessment used is only a type of intra-company benchmark, and therefore, it inherently assumes that Endeavour's historical practices and augex were prudent and efficient. We have not tested the validity of this assumption in our analysis.

1 Introduction

1.1 Background and scope

Endeavour Energy (Endeavour) has engaged us, Nuttall Consulting, to assist in its preparations for its next regulatory decision by the Australian Energy Regulator (AER). This decision will cover the five-year period from 1 July 2019 to 30 June 2024.

As part of this engagement, Endeavour has requested that we:

- develop a model of Endeavour's augmentation capital expenditure (augex) using the AER's augex model
- use the model to assess Endeavour's augex forecast, using an approach that could be applied by the AER
- reconcile the model forecast with Endeavour's own augmentation forecast
- prepare an independent report, which can be used as a supporting document to Endeavour's building block proposal to the AER, that sets out the forecast and explains how we developed the model and forecast.

The augex model can be considered a top-down tool to analyse and forecast utilisation-related network augmentations. Endeavour has advised that a significant portion of its augex is driven by new (greenfield) developments. It considers that the augmentations associated with these developments are more weakly related to the utilisation of its existing network. Therefore, Endeavour has requested that we use the model to assess two scenarios:

- augmentations due to organic demand growth only (which will be strongly related to network utilisation)
- augmentations due to organic and greenfield demand growth (which will be more weakly related to network utilisation).

This document serves as the report to Endeavour indicated above.

The following definitions are used in this report:

- **Augmentation capex** (or **augex**) has the meaning given to it by the AER in its recent advice on how it will conduct expenditure forecast assessments, which broadly covers the demand-driven reinforcement, extension or enhancement of the network, excluding similar activities due specifically to the connection of customers.
- We use the term **AER augex model** to mean the generic excel workbook that the AER has advised it will use as an assessment technique in its determinations – and the AER calls the augex model.

- We use the term **Endeavour augex model** to mean the model we have prepared of Endeavour's network using the AER augex model. The Endeavour augex model is used here to produce augex forecasts of the Endeavour network.
- We use the term **asset** here in a very general sense to reflect the physical unit of network that is accounted for in the AER augex model. This typically reflects an individual line or an individual substation[5].
- When discussing the model and providing results in Sections 2 and beyond, we will use the year representation 200*x*, to represent the regulatory year 200*x*-1/200*x.*

In addition, all expenditure and costs shown in this report represent **direct real June 2019 dollars**.

1.2 Nuttall Consulting experience in this task

Nuttall Consulting, using Dr Brian Nuttall (the author of this report), developed the Excel workbook that serves as the basis of the AER's augex model and advised the AER on its possible roles and application in regulatory determinations.

Moreover, we were engaged by the AER to provide advice that informed the AER's past determinations of the Victorian and Tasmanian Distribution Network Service Providers (DNSPs). As part of these engagements, Dr Nuttall developed models and forecasts using the AER's repex model. Although the augex model is aimed at a different expenditure activity (network augmentation, rather than asset replacement) it is broadly based upon similar principles. We have been engaged by a number of DNSPs to assess their augex forecasts using the augex model and an approach that is similar to that used by the AER when applying the repex model to assess repex. This is the same approach we have used here.

1.3 Key information sources

We have used the following key information to develop Endeavour's augex model:

- the AER augex model and AER augex model handbook, published on the AER website
- asset loading and rating data, provided in the format of the asset status tables in Template 2.4 of the Reset Regulatory Information Notice (RIN); this data covers the two years 2013/14 (2014) and 2017/18 (2018)[6]
- Endeavour's historical augex covering the period from 2013/14 to 2016/17, and Endeavour's forecast augex covering the period from 2017/18 (2018) to 2023/24 (2024), as defined in Table 2.4.6 of the Reset RIN.

[5] Note the difference here to an asset in the repex model – or Endeavour' systems – which is likely to account for a sub component of the augex model's asset.

[6] Note, we understand that the data reporting for each of these two years corresponds to the asset loading and rating entering these years.

- Endeavour’s forecast augmentation capacity added to its network covering the period from 2017/18 (2018) to 2023/24 (2024), as defined in Table 2.4.6 of the Reset RIN.

We have also held a number of workshops with relevant Endeavour personnel to clarify data requirements. Where gaps exist, we have made a number of assumptions based on advice from Endeavour to prepare the models. The critical assumptions and their basis will be discussed in this report.

1.4 Structure

This report is structured as follows:

- In section 2 we provide an overview of the AER augex model, summarising how it develops a forecast, its inputs and outputs, and how the AER may use it to assess a DNSP’s augmentation forecasts.
- We discuss the methodology we have used to develop the Endeavour augex models in Section 3.
- In Section 4 we explain the approach we have used to assess Endeavour’s augex forecast using the augex model
- Section 5 summarises and discusses the results of this assessment.

2 The AER's augex model

Before explaining the development of Endeavour's augex model, we first provide an overview of the AER's augex model and its application. This should help provide some context to the results and discussions in the sections that follow.

2.1 Overview of augex model

The AER augex model is an Excel workbook, with a structure, formulas and VBA functions and macros set up by the AER in order that it can be used by the AER to develop a network model of a DNSP and use this to prepare augex forecasts.

The DNSP's network is constructed within the AER augex model as a series of asset populations. The model uses a probabilistic augmentation algorithm to make predictions of augmentation needs for each population. The probabilistic augmentation algorithm assumes that the maximum utilisation that an asset will reach before it must be augmented (called its utilisation threshold in the model) is normally distributed across any asset population represented within the model.

From this, the model predicts future augmentation volumes based upon a current utilisation profile for an asset population represented in the model and forecast growth in demand (which is used as a proxy for the forecast growth in utilisation).

The AER has indicated that it will use this model to make top-down assessments of a DNSP's augex forecast. In this regard, it has indicated that it may use the model in two ways to develop a benchmark forecast:

1. **Intra-company** – it will develop a benchmark forecast within the model that reflects the historical augmentation decisions of the DNSP (this reflects an assumption that these decisions were prudent and efficient)
2. **Inter-company** – it will develop a benchmark forecast within the model that reflects its view of the appropriate augmentation decisions it has determined from the set of DNSPs (this reflects an assumption that the DNSP's decisions may not have been prudent and efficient, and so it has substituted its view on this matter from the augex models of other DNSPs to test this).

It is important to stress that at this stage the AER has not published any of its analysis of the above forms of benchmarking. As such, it is unclear how it may approach the assessment of Endeavour's augex forecast.

Importantly, it has not published any inter-company benchmark parameters for this model. Therefore, we only discuss **intra-company** benchmarks in this report. As such, the forecast produced by the model in this report is only reflected of Endeavour's recent historical augmentation and augex levels, and assumes that these to reflect prudent and efficient decisions.

2.2 AER augex model form, inputs and output

2.2.1 Network specification inputs – network segments and groups

As indicated above, a DNSP's network is defined as a series of distinct asset categories within the augex model. These are called network segments in the AER's documentation and represent the set of network assets that may have similar planning arrangements i.e. lines or substations.

To facilitate analysis and reporting, each network segment defined in the model is assigned to a smaller set of groups. In this way, a model may use a large number of network segments, to improve the accuracy of the analysis, but a much smaller number of groups to provide aggregate forecasts for reporting (and benchmarking) purposes.

2.2.2 Network specification inputs - utilisation profile

A utilisation profile must be provided for each network segment used in the model. This profile represents a snap-shot of the utilisation of the population of assets in that segment for the initial year of the model. That is, the utilisation profile is essentially a vector that holds the volume of assets (measured in capacity units e.g. MVA) at one-percentage increments of utilisation.

The timing of a capacity-related augmentation is typically sensitive to the maximum demand on an asset. That is, it is the amount of the maximum demand that is above various capacity limits of an asset that defines the risks and/or service constraints associated with using the asset. Therefore, within the augex model, the <u>utilisation</u> of any asset (e.g. the utilisation of a line or substation) is defined as:

- *the maximum demand on that asset / the assets capacity limit or rating*.

The model itself does not define exactly how the measures of maximum demand or capacity must be specified. However, the AER has indicated its preference for these measures in an effort to place all DNSPs on a consistent basis[7], where:

- the maximum demand should be weather corrected to represent a 50% probability of exceedance condition (and reflect normal network arrangements)
- the capacity of an asset should reflect its thermal rating, assuming a normal load cycle if applicable (i.e. an asset's normal cyclic rating).

It is important to note that once the units of capacity in a segment are defined, all measures of utilisation, capacity being augmented, or capacity needing to be augmented are reported in the model on that basis.

2.2.3 Network specification inputs – utilisation growth

To predict a network's augmentation *needs*, the model must first predict what the utilisation of the network will be in the future. To do this, the model requires the growth

[7] See discussion in Section 5 of AER augex model manual.

in utilisation (assuming no augmentation) to be input for each network segment. This is essentially the growth in maximum demand for each network segment.

The model represents this growth as a single annual compounded growth rate (percentage growth in one year) that should represent the average annual growth rate over the period being considered (note here that the model does not hold individual growth rates for each year of the forecast period).

2.2.4 Planning parameters inputs

The model uses four planning parameters to define the approach it uses to predict future augmentation *needs*:

- The utilisation threshold, which is represented as a normal probability distribution, is defined by two of these parameters:
  - the mean utilisation threshold
  - the standard deviation of the utilisation threshold.

  The utilisation threshold specifies when existing capacity requires augmentation, and is used to measure this amount from the utilisation profile. In this way, this parameter defines how the *need* for augmentation is measured.

- The capacity factor is the third parameter, reflecting the amount of additional capacity that is added to the network, given the amount of existing capacity that requires augmentation. It is defined as a proportion of the capacity requiring augmentation.

  For example, if the capacity factor is set at 50%, this means that if the model calculates that 100 MVA of the existing capacity will require augmentation in the future then it will assume that 50 MVA of capacity will be added to the network to address that need.

  This parameter relates to the *scale*, in capacity terms, of the augmentation solution that is used to address a *need*.

- The fourth parameter reflects the average augmentation unit cost, where a unit is specified in terms of the relevant unit of capacity for that network segment (i.e. $ / kVA of capacity).

Using these parameters, the capacity added to the network, calculated via the utilisation threshold and capacity factor, multiplied by the augmentation unit cost produces the expenditure forecast.

2.2.5 Model outputs

The model produces various outputs. These outputs provide various measures of the input utilisation profile, such as average utilisation, average threshold, total quantity of capacity, and total augmentation cost (i.e. quantity x augmentation unit cost).

The model also produces forecasts (by year over a 20-year period), including augmentation capacity volumes, augmentation expenditure, and average utilisation.

These outputs are provided at the network segment, segment group and total network level. When averages are calculated at the network group or network level, the model uses a weighted average using the augmentation cost of each asset category as the weighting.

2.3 Calibration

The calibration of a DNSP's model is the critical process that is applied by the AER (and us for this assessment) to produce the intra-company benchmark model.

The calibration process concerns deriving the set of model planning parameters that reflects the actual augmentation outcomes (volumes and expenditure) over the calibration period.

The following process can be used to calibrate the augex model[8].

This process relies on calculating three parameters for each network segment (or segment group) from the available data, namely:

- the augex in that segment (or segment group) over the calibration period
- the capacity added (through augmentation) in that segment (or segment group) over the calibration period
- the capacity that required augmentation in that segment (or segment group) over the calibration period.

2.3.1 Augmentation unit cost

The augmentation unit cost parameters for each segment is simply the augex divided by the capacity added to the segment.

2.3.2 Volume planning parameters

The utilisation threshold parameters (mean and standard deviation) and capacity factor for each segment need to be set to ensure the model reflects the capacity added (through augmentation) over the calibration period.

However, the calculation of these planning parameters is more complicated because:

- we have three parameters to determine and typically only one variable (the total capacity added)
- we are looking at history and not predicting into the future.

[8] The AER augex model manual does not discuss the calibration process in any detail. However, we understand the AER will apply a similar process to the one it has indicated it will use to calibrate its repex model. The process we have defined here should reflect this similar process.

Therefore, the calibration of the utilisation threshold parameters is slightly more involved and involves the following:

- First, in the absence of better information, the need to determine the standard deviation is removed by making it dependent on the mean. We have assumed that the standard deviation is the square root of the mean to reflect a similar assumption the AER has advised it will use for the repex model calibration process.
- Second, the capacity factor is set at a specific value. There are various ways this could be calculated. Here, Endeavour has estimated this parameter for our assessment by analysing a sample of its recent augmentation projects.
- Third, an augex model is developed to reflect the beginning of the calibration period, with the growth set to represent the growth that occurred over the calibration period. The mean utilisation is determined within this model to ensure that the forecast produced by the model over the calibration period equals actual capacity added due to augmentations during the calibration period.

The above defines the process that will typically be applied.

3 Endeavour augex model development

3.1 Overview

As discussed in Section 2.3, the process to calibrate a model and prepare a forecast requires the preparation of two augex models:

- The calibration model – This model is developed from the 2013/14 loading and rating data. The planning parameters are calculated within this model to ensure the forecast produced by the model to 2018 (i.e. capacity added and augex) matches what actually occurred.
- The forecast model – This model is developed from the 2017/18 loading and rating data. This model is used to prepare the forecasts over the next period, using the planning parameters developed in the calibration model.

The development of these two models, including the parameter calibration process, is discussed in this section.

3.2 Augex model development

3.2.1 Segmentation

The model produces forecasts for a set of network segments that represent the DNSP's network. As such, each segment defined in the model requires its own set of inputs (i.e. utilisation profile and planning parameters) and the model produces forecasts for each segment.

Segments have been developed that largely reflect those model categories, defined by the AER in its Reset RIN, which are relevant to Endeavour. We have added and altered some categories to improve the accuracy of the modelling, as follows:

- we have segmented the sub-transmission line group by nominal voltage
- we have segmented the zone substation group by substation transformer numbers
- we have combined short rural and long rural HV feeders in to a single rural segment as we considered that there were too few long rural feeders to justify these being modelled separately.

The table below summarises the groups and segments we have developed for the Endeavour augex models.

Table 1 Endeavour augex model network segments

Network group	Network segment
Sub-transmission lines	132 kV 66 kV 33 kV
Transmission and zone substations	Transmission substations Zone substations (1 transformer) Zone substations (2 transformers) Zone substations (3 or more transformers)
HV feeders	Urban Rural all
Distribution substations	Urban Short Rural Long Rural

3.2.2 Utilisation profiles

Utilisation definition

In the model, the utilisation of an asset (e.g. an HV feeder or zone substation) is defined as:

Utilisation (%) = weather corrected peak demand (MVA) / asset rating (MVA).

For each segment, two utilisation profiles have been prepared reflecting the loading in 2013/14 and 2017/18. These profiles use the following asset ratings defined in the asset status tables of template 2.4 of the Reset RIN.

Table 2 augex model asset rating definitions

Network type	asset rating
Sub-transmission lines	normal cyclic thermal rating
Transmission and zone substations	substation normal cyclic thermal rating
HV feeders	normal thermal rating
Distribution substations	normal cyclic thermal rating

It is important to note that any capacities referred to in this report as inputs or outputs of the Endeavour augex model are measured on the above basis. This also includes any references to utilisation and the augmentation unit costs.

Scaling of distribution substation ratings in the augex models

Endeavour has a material portion of distribution substations with a very high utilisation, which is near or above the model's maximum utilisation input limit (150%). Therefore, to ensure that this limit does not affect our modelling, we have scaled the distribution rating by a factor of two and performed all calibration and modelling using this scaling.

In our experience, there is nothing unusual in applying this scaling to Endeavour's distribution substations. We have applied similar scaling in the models we have prepared for all other DNSPs. We do not consider that this scaling should have a material effect on the validity or accuracy of the model's forecast.

To avoid confusion, in the tabulated results presented in this report, we show unscaled values in order that they can be readily interpreted by Endeavour. However, we also present the scaled values in brackets in order that they can be reconciled to the model files.

Summary model inputs

The utilisation profiles need to be viewed through the augex model. However, to aid in the validation of the model, the following table summarises some important parameters associated with this set of profiles.

Table 3 Summary loading, rating and utilisation data in the augex models

Segment	Weather correct peak demand (MVA)		Asset capacity (MVA)		Average utilisation (%)		Asset capacity >100% utilisation (MVA)	
	2014	2018	2014	2018	2014	2018	2014	2018
132 kV	*5330*	*6498*	*23290*	*27902*	*23*	*23*	*0*	*0*
66 kV	*1217*	*1465*	*5873*	*6448*	*21*	*23*	*0*	*22*
33 kV	*2941*	*3865*	*11207*	*12346*	*26*	*31*	*50*	*96*
All sub-transmission lines	**9488**	**11828**	**40370**	**46696**	**24**	**25**	**50**	**118**
Transmission	*2388*	*2446*	*6164*	*6524*	*39*	*37*	*0*	*0*
zone (1 transformer)	*34*	*88*	*100*	*255*	*34*	*35*	*0*	*0*
Zone (2 transformers)	*1467*	*1742*	*4509*	*5069*	*33*	*34*	*0*	*0*
Zone (3 or more transformers)	*1890*	*1911*	*4307*	*4720*	*44*	*40*	*105*	*0*
All transmission and zone substations	**5778**	**6187**	**15081**	**16569**	**38**	**37**	**105**	**0**
Urban HV feeders	*3516*	*3777*	*5991*	*7156*	*59*	*53*	*261*	*214*
Rural HV feeders	*552*	*544*	*1286*	*1470*	*43*	*37*	*45*	*11*
All HV feeders	**4069**	**4320**	**7278**	**8625**	**56**	**50**	**306**	**225**
Urban substations	*4008*	*4134*	*7670 (15341)*	*8084 (16167)*	*52 (26)*	*51 (26)*	*312 (625)*	*308 (617)*
Short Rural substations	*790*	*852*	*1557 (3114)*	*1763 (3526)*	*51 (25)*	*48 (24)*	*42 (84)*	*51 (102)*
Long Rural substations	*3*	*2*	*4 (9)*	*5 (10)*	*67 (33)*	*48 (24)*	*0 (0)*	*0 (0)*
All distribution substations[a]	**4801**	**4988**	**9232 (18464)**	**9852 (19703)**	**52 (26)**	**51 (25)**	**354 (708)**	**359 (719)**

a – brackets indicate distribution substation parameters, allowing for the rating scaling that is applied in the model

3.2.3 Load growth

For each segment, the growth in peak demand is an important input that drives the forecast. The growth rates used in the two augex models (noted in the introduction to this section) are calculated as the average annual compound growth rate as follows:

- for the calibration model, the growth rates reflect the weather corrected peak demand from 2013/14 to 2017/18
- for the forecast model, the growth rates reflect the weather corrected peak demand from 2017/18 to 2023/24.

To calculate the growth rate to be applied in the model for each segment, the overall growth rate in peak demand can be considered to consist of three components:

- demand growth due to new connections associated with that segment, which is driving expenditure that Endeavour has allocated to the AER's connections expenditure category, and which is considered to drive expenditure that is not related to the utilisation of assets in this segment (and so should not be modelled)
- demand growth due to greenfield developments, which is driving expenditure that Endeavour has allocated to the AER's augmentation expenditure category, and which is considered to drive expenditure that is weakly related to the utilisation of assets in this segment
- demand growth due to organic demand growth (noting this could be due to new connections that are occurring downstream of this segment), which is driving expenditure that Endeavour has allocated to the AER's augmentation expenditure category, and which is considered to drive expenditure that is strongly related to the utilisation of assets in this segment.

The effects of the first of these components is not assessed through the augex model. The effects of the other two components (greenfield and organic growth) can be assessed through the augex model, and define the growth rates that are used in the two scenarios Endeavour has requested us to assess. We have estimated these components from data Endeavour provided on the percentage split of the capacity added for each network group (see the discussion in Section 3.3.2).

For the historical growth rates used to drive the calibration model, we have calculated the total demand growth for each segment group, based upon the growth that can be determined from the aggregate maximum demands of the two utilisation profiles (as shown in Table 3). The percentage splits noted above have been used to apportion this total growth between the various components of growth.

For the forecast growth rates used to drive the calibration model, Endeavour has advised the following network level compound average annual growth rates that can be used to drive the model:

- total growth rate (organic plus greenfield) of 2.7% per annum
- organic only growth rate of 1.5% per annum.

We have used the variation in growth rates calculated between network segment groups seen in historical data, to adjust the network-level forecast growth rates for each segment group. It is worth noting that it is important to replicate these variations to ensure that the model planning parameters we calculate from the historical calibration process are applicable to the forecast period.

Table 4 below summarises the segment group growth rates used in the Endeavour augex model, calculated using the methodology described above.

Table 4 Augex model growth rates

Segment	Historical		Forecast	
	organic	all	organic	all
All sub-transmission lines	1.76%	4.25%	2.76%	6.64%
All transmission and zone substations	0.73%	1.73%	1.14%	2.70%
All HV feeders	0.44%	1.04%	0.69%	1.63%
All distribution substations	0.09%	0.10%	0.14%	0.15%

In appreciating the differences in growth rates between segments, it is worth noting the following:

- **Sub-transmission lines** - We understand that Endeavour has implemented a number of historical projects, which form new “tees” into existing lines. Because of how the model aggregates individual line loading and rating in each segment, it can see such changes as an increase in total demand (and total rating). Hence, we would expect to see higher growth rates in these situations.
- **Distribution substation** – This group has a significantly lower growth rate because the majority of growth in these segments is directly due to new customer connections, and so is not factored into this model.

These matters should not affect the forecasting in the model because of how the model develops its forecast, and the inherent assumption that this forecast reflects an intra-company benchmark referenced back to Endeavour’s recent history. However, care should be taken in using these growth rates for any other purpose or comparing them to growth rates prepared for other purposes.

3.3 Model calibration

3.3.1 Historical calibration period

The historical calibration period reflects the 4-year period prior to the base year, but inclusive of it. As such, the calibration period covers the commencement of 2013/14 to the commencement of 2017/18. That is, the model is calibrated to reflect the augmentations (i.e. the capacity added and augex allocated to the AER augmentation expenditure category) that occurred from 2013/14 to 2016/17 inclusive.

3.3.2 Set up of calibration data

As discussed in Section 2.3, the initial phase in calibrating the augex model, involves determining three parameters for each segment. The parameters reflect the augmentations that have occurred over the calibration period, namely:

- the augex
- the incremental capacity added (because of demand-driven augmentations only)
- the capacity factor.

The table below summarises these parameters for each segment in the Endeavour augex model, indicating the portions of augex and capacity added in the organic and greenfield components.

Table 5 Augex model calibration parameters

Segment	capacity added		augex		Capacity factor
	organic	greenfield	organic	greenfield	
	(MVA)	(MVA)	$ (millions)	$ (millions)	(MVA)
132 kV	*1245*	*1753*	*62.3*	*44.1*	*0.73*
66 kV	*155*	*218*	*7.8*	*5.5*	*0.59*
33 kV	*308*	*433*	*15.4*	*10.9*	*0.71*
All sub-transmission lines	**1708**	**2404**	**85.5**	**60.5**	**0.73**
Transmission	*137*	*187*	*18.5*	*3.3*	*0.59*
zone (1 transformer)	*0*	*0*	*0.0*	*0.0*	*0.71*
Zone (2 transformers)	*21*	*29*	*2.9*	*3.8*	*0.71*
Zone (3 or more transformers)	*408*	*558*	*55.7*	*74.4*	*0.71*
All transmission and zone substations	**566**	**774**	**77.1**	**81.5**	**0.67**
Urban HV feeders	*338*	*466*	*39.1*	*3.4*	*0.58*
Rural HV feeders	*53*	*73*	*4.9*	*0.8*	*0.58*
All HV feeders	**391**	**539**	**44.0**	**4.2**	**0.58**
Urban substations	*37 (74)*	*4 (8)*	*1.1*	*0.1*	*0.50*
Short Rural substations	*19 (37)*	*2 (4)*	*0.7*	*0.1*	*0.50*
Long Rural substations	*0 (0)*	*0 (0)*	*0.0*	*0.0*	*0.50*
All distribution substations[a]	**56 (111)**	**6 (12)**	**1.8**	**0.2**	**0.50**

a – brackets indicate distribution substation parameters, allowing for the rating scaling that is applied in the model

These parameters have been calculated using the following methodology and assumptions.

Capacity added

The capacity added in each segment has been determined by first calculating the total capacity added (for any reason) in each segment. This calculated as the difference in the total capacity for each segment from 2013/14 to 2017/18 (see segment totals in Table 3).

At the segment group level, Endeavour has provided the proportion of capacity added for different drivers, as shown in Table 6 below. The organic and greenfield proportions associated with augex have been used to scale the associated segment total capacity added to produce the two components defined in the table above.

Table 6 Capacity added to driver assumptions

Category	organic growth with expenditure allocated to augex (strongly utilisation relation)	greenfield/customer developments with expenditure allocated to augex (weakly utilisation related)	asset replacements, with expenditure allocated to repex (not utilisation related)	greenfield/customer developments with expenditure allocated to connections (not utilisation related)
Sub transmission feeders	27%	38%	10%	25%
HV Feeders	29%	40%		31%
Zone substations	38%	52%	10%	0%
DSS	9%	1%		90%

Augex

The augex parameters have been calculated directly from the historical augex defined in table 2.4.6 of the reset RIN. Where required, the capacity added in a segment has been used to apportion augex defined at the segment group level to individual segments.

Capacity factors

Endeavour has provided the capacity factors for use in each segment group. Endeavour has estimated these capacity factors from samples of representative projects.

3.3.3 Determining planning parameters

The calibration of the planning parameters is performed using the calibration model. This model is populated using the 2013/14 utilisation profiles and historical load growth, as explained above. The planning parameters for each segment are calibrated to ensure the calibration model outputs the parameters set out above (in Table 5).

This calibration process can be consider in two steps:

- calculating the unit cost
- calculating the utilisation threshold parameters.

These two steps are discussed in turn below.

3.3.3.1 Calculating the unit cost

We have calculated the augmentation unit costs ($/kVA) for each segment, directly using the parameters shown in Table 5:

- For the organic only scenario, the unit costs is simply augex driven by organic growth / capacity added due to organic growth.
- Similarly, for the organic and greenfield scenario, the unit cost is augex driven by organic growth and greenfield growth / capacity added due to organic and greenfield growth.

3.3.3.2 Calculating the utilisation threshold parameters

The utilisation threshold for each segment is determined through the calibration model by finding the threshold value that forces the model to forecast the capacity that was known to have been added over the calibration period.

The following process has been used to apply this approach:

1 Input the unit cost and capacity factor planning parameters in the calibration model

2 Assume the standard deviation of the utilisation threshold, for each segment, is the square root of the mean for that segment.

3 Using the model, determine the mean utilisation threshold parameter that sets the model's forecast of capacity added to the network over the calibration period to be equal the actual capacity added in the relevant segments. Excel's goal seek function is used for this purpose.

This has been applied twice to cover the two scenarios defined by Endeavour:

- For the organic only scenario, the capacity added and growth rates for organic growth only are applied.
- Similarly, for the organic plus greenfield scenario, the capacity added and growth rates for organic and greenfield growth rates are applied.

3.3.3.3 Scenario planning parameters

Table 7 Augex model calibrated planning parameters

Segment	mean utilisation threshold		unit cost	
	organic	organic + greenfield	organic	organic + greenfield
	(%)	(%)	$/kVA	$/kVA
132 kV	*46.1*	*45.0*	*50.0*	*35.5*
66 kV	*63.8*	*61.4*	*50.0*	*35.5*
33 kV	*76.7*	*74.4*	*50.0*	*35.5*
All sub-transmission lines	**57.1**	**53.1**	**50.0**	**35.5**
Transmission	*66.2*	*63.1*	*135.5*	*67.3*
zone (1 transformer)	*95.9*	*97.8*	*136.7*	*134.8*
Zone (2 transformers)	*57.0*	*57.9*	*136.7*	*134.8*
Zone (3 or more transformers)	*50.4*	*46.8*	*136.7*	*134.8*
All transmission and zone substations	**57.3**	**54.1**	**136.4**	**118.4**
Urban HV feeders	*71.9*	*66.9*	*115.7*	*52.9*
Rural HV feeders	*71.1*	*65.3*	*91.7*	*44.6*
All HV feeders	**71.8**	**66.7**	**112.5**	**51.8**
Urban substations	*83 (41)*	*83 (41)*	*29.5 (14.8)*	*29.5 (14.8)*
Short Rural substations	*60 (30)*	*60 (30)*	*38.9 (19.5)*	*38.9 (19.5)*
Long Rural substations	*65 (33)*	*65 (33)*	*237.5 (118.8)*	*237.5 (118.8)*
All distribution substations[a]	**77 (39)**	**77 (39)**	**32.8 (16.4)**	**32.8 (16.4)**

a – brackets indicate distribution substation parameters, allowing for the rating scaling that is applied in the model

Table 7 above summarises the segment mean utilisation threshold and unit cost used in the Endeavour augex model, calculated using the calibration method described above. This table shows the parameters that have been calibrated for the two growth component scenarios defined by Endeavour.

4 Augex forecast assessment

In this section we discuss our assessment of Endeavour's augex forecast for the two scenarios defined by Endeavour:

- organic growth only augmentations
- organic and greenfield growth augmentations.

In keeping with the AER's recent approach to the use of its repex model, this assessment is focused on the *aggregate* augex forecast over Endeavour's next regulatory period, 20119/20 (2020) to 2023/24 (2024).

4.1 Model assessment results

Table 8 summarises the Endeavour forecast and comparable augex model's forecasts for the two scenarios assessed. The results are provided as the total augex forecast over the next 5-year regulatory period.

Table 8 Augex model study results summary

	Forecast 2019/20 – 2023/24 ($ millions)	
Scenario	Endeavour	Model
Organic only	88.4	305.2
Total (organic + greenfield)	397.6	589.1

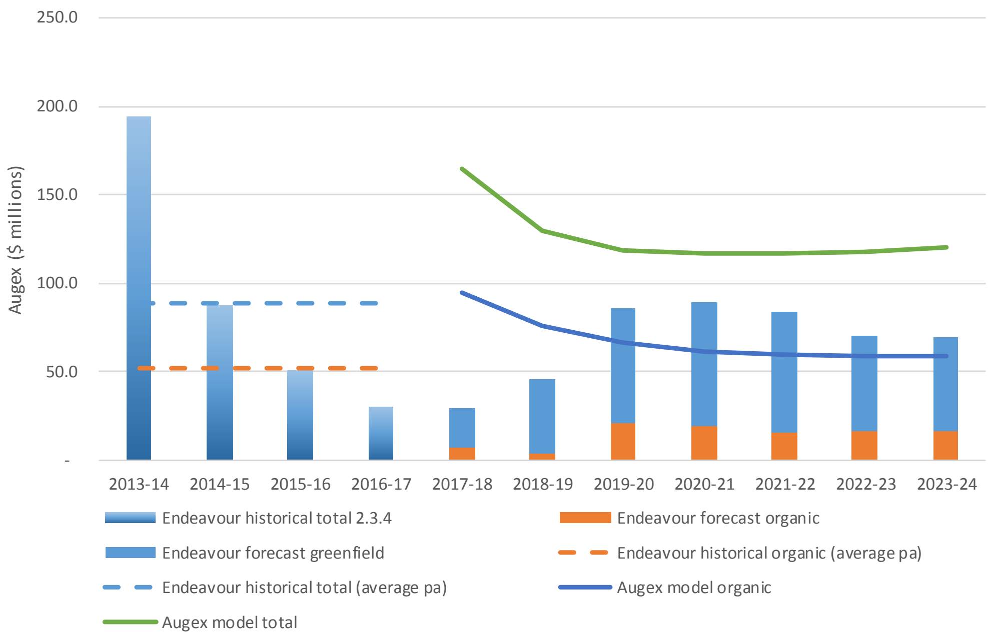

Figure 1 intra-company study results

The profile of Endeavour's historical and forecast augex compared to the model's forecasts are shown in Figure 1. For both scenarios, the comparable average per annum historical augex over the calibration period is shown. The figure also shows the profile of historical reported augex, as reported to the AER in table 2.3.4 of Endeavour's various category analysis RINs.

4.2 Assessment discussion and conclusions

The assessment using the augex model supports Endeavour's forecast.

- The model assessment provides very strong support to Endeavour's augex forecast associated with the organic demand growth only scenario. Endeavour's forecast of $88 million for this scenario is well below the equivalent forecast produced by the model, with Endeavour's forecast at only 29% of the model's forecast of $305 million.
- The model assessment also supports Endeavour's augex forecast when both organic and greenfield demand growth is included. Endeavour's forecast of $398 million is below the equivalent forecast produced by the model, with Endeavour's forecast at 67% of the model's forecast of $589 million.

With regard to these results, it is notable that Endeavour's forecast for the organic growth component is expecting a significant reduction (66% reduction) from the average historical level over the calibration period. However, the augex model is forecasting a modest increase (17% increase). The increase forecast by the model is not unexpected, given the model's planning parameters are calibrated to history and the driving forecast demand growth is significantly higher than the historical growth associated with the calibration period (e.g. 0.73% per annum historically compared to a forecast growth of 1.14% per annum for zone substations).

It is also worth noting that Endeavour has advised that the first year of the calibration period, 2013/14, captured some augmentations that were associated with augmentations to comply with its previous licence conditions which defined network planning criteria. These criteria were more onerous than its current criteria. This may explain, at least in part, the significant difference between Endeavour's forecast and the augex model.

With regard to the scenario allowing for both organic and greenfield results, the reduced difference between the Endeavour and model forecasts suggest that Endeavour's augex forecast of the greenfield only component could be slightly above what is being forecast by the model for this component only.

That said, it is not feasible to separately model these two components, and some care must be taken in inferring the greenfield component from these results. We understand that the greenfield component allows for augmentations that are more weakly related to the utilisation of the existing assets. However, the strength of the relationship with utilisation would be different for different augmentations. Some, and possibly many, could still be fairly strongly related. Therefore, this may also explain why the forecast produced by the model for the organic only component of demand growth is so much lower than Endeavour's forecast, as more of the greenfield component should be fully comparable through the model with the organic growth component.

Finally, it is also worth noting that both Endeavour and the model are forecasting that augex per unit of demand growth will reduce significantly from historic levels. The total demand growth is forecast by Endeavour to increase by a factor of approximately 1.6 from historical levels (e.g. 1.7% per annum historically compared to a forecast growth rate of 2.7% per annum). The model predicts total augex only needs to increase by a factor of 1.3 due to this increase in demand growth. Endeavour on the other hand is forecasting a much more significant reduction in augex than predicted by the model, with Endeavour's forecast of total augex reducing by 10% compared to historical levels.

In conclusion, we consider this assessment to be a reasonable top-down guide to Endeavour's augmentation needs, of which the results provide a form of supporting independent regulatory challenge to Endeavour's own augex forecast. However, it is important to stress that the assessment used is only a type of intra-company benchmark, and therefore, it inherently assumes that Endeavour's historical practices and augex were prudent and efficient. We have not tested the validity of this assumption in our analysis.