Guidance document

AER Augmentation model – data requirements

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AUSTRALIAN ENERGY REGULATOR

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1 Introduction

The Australian Energy Regulator (AER) is to undertake an assessment of the appropriate distribution determination to be applied to the direct control services provided by the New South Wales (NSW) distribution network service providers (DNSPs) for the period 1 July 2014 to 30 June 2019 (the next regulatory control period).

As part of this process, the AER must assess the capital expenditure (capex) forecasts for the next regulatory control period that are provided in each DNSP's regulatory proposal to the AER.

In accordance with the requirements of the National Electricity Rules (NER), the AER uses various approaches and tools to assess the DNSP's capex forecasts. One tool it has developed and used in recent distribution determinations aids in its assessment of capex to replace aging assets – replacement capex. This tool is known as the repex model and uses high-level asset data to predict future asset replacement volumes and capex.

The AER is considering the implementation of a similar tool to aid in its assessment of capex to augment the network (i.e. capex primarily required to increase the capacity of a network to allow for load growth) – augmentation capex[1].

The AER has engaged Nuttall Consulting to develop such a tool. As part of the terms of reference for this assignment, Nuttall Consulting has been requested to prepare a guidance document on the information requirements to populate the model. This guidance document is to cover the collection, calculation, use and/or presentation of data to be requested in Regulatory Information Notices (RINs) issued to the DNSPs by the AER.

This report to the AER covers this requirement. As such, although this document has been written for the AER, it is assumed that the core of the document will be used by the AER to prepare relevant RINs. This guidance document is supported by a data template: "augmentation model data template.xls", which would be used by the AER to collect model input data from the DNSPs.

The document is structured such that in Section 2 a brief overview of the model is provided. It is intended that this discussion would form part of the RIN with the aim of providing context to the DNSPs of the information requests. Section 3 details the information requests.

[1] In some states *augmentation* is defined as *reinforcement*.

2 AER augmentation tool

2.1 Introduction

This section provides a brief overview of the tool the AER is considering using as part of its assessment of the augmentation capex of the DNSPs. The aim of this section is to provide an overview of the model, including its data inputs, in order to provide some context to the information requests in the data template and below.

2.2 Augmentation and model overview

A major portion of most DNSP's capex is due to the need to augment the network (i.e. upgrade existing asset capacity or add new capacity) to account for changes in the customer demand for electricity.

The AER is developing a tool to aid in its assessment of augmentation capex – the augex model. The overall philosophy behind the model's functionality, in a regulatory context, is similar to the repex model the AER presently uses to assess age-related replacement capex. In this regard, the augex and repex models provide a useful reference to assess regulatory proposals, allowing a common framework to be applied without the need to be overly intrusive in data collection and the detailed analysis of the asset management plans.

The augex model forecasts augmentation needs at an aggregate level using asset utilisation as the main asset state that drives this need - where asset utilisation is taken to mean the proportion of the assets capability being used during peak demand conditions. The model then uses idealised planning parameters to predict future augmentation needs given this asset utilisation.

In this way, the augex model takes account of the main internal drivers of augmentation capex that may differ between DNSPs, namely peak demand growth and its impact on asset utilisation. Similar to the repex model, the augex model can be used to determine intra- and inter-company benchmarks from actual historical augmentation levels. These in turn can be used to identify elements of a DNSPs augmentation capex forecast requiring more detailed review and inform the appropriate expenditure allowances.

2.3 Model form

2.3.1 Segmentation and grouping

The augex model represents a DNSP's network as a set of user-definable network segments. The segments represent the network assets that may be grouped together for assessing augmentation needs. Generally, this means that a segment would represent either a set of substations or lines[2].

To aid in the analysis within the model and presentation of results, individual network segments can be aggregated to up to 12 separate segment groups. The grouping we propose is shown in

Table 1.

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[2] Note the difference here with the repex model, which defines individual categories at an asset level. As such, it may be expected that the augex model will have fewer individual network segments that the repex model will have asset categories.

Table 1 Segment groups

Group ID	Group
1	Sub-transmission lines
2	Sub-transmission substations
3	Zone substations
4	HV feeders – CBD
5	HV feeders – urban
6	HV feeders – short rural
7	HV feeders – long rural
8	Distribution substations – CBD
9	Distribution substations – urban
10	Distribution substations – short rural
11	Distribution substations – long rural

The intention is that the DNSP will suggest the individual network segments in each segment group. It may be however that the AER will adjust these segments based upon the raw data provided by the DNSPs in the data template and responses to questions given below.

2.3.2 Segment data

For each network segment in the model, two types of input data are required:

- Asset status data
- Planning parameters.

2.3.3 Asset status data

The asset status data is used to develop the future profiles of asset utilisation for that segment. The input data covers the following:

- Asset utilisation profile snapshot – This data set represents a snapshot of the existing profile of asset utilisation for that segment for a particular year. The year of the snapshot represents the starting point that the forecast is made from. The utilisation profile can be considered a vector where each element represents the capacity (in MVA terms) of assets in that segment at a particular utilisation level.

- Asset utilisation growth rate – For each segment, a growth rate is defined that represents the average annual compound rate of growth in utilisation over the forecast period, assuming the network is not augmented. It is anticipated that this growth rate will reflect the growth in peak demand that is relevant for the assets contained in that segment.

The above two sets of input data will be derived directly from the DNSP data provided in the augmentation data template, based upon the raw maximum demand and rating data provided on the "asset status" sheets.

Planning parameters

The planning parameter input data is used to forecast the capacity added to the network, and the cost of that capacity, from the future profiles of asset utilisation for that segment. Three planning parameters are defined for each segment as follows:

- Utilisation threshold – The utilisation threshold defines the utilisation limit when augmentation must occur. As with the repex model, the augex model uses a probabilistic algorithm to determine the amount of the existing network requiring augmentation. This algorithm assumes a normal distribution and requires the mean and standard deviation for this distribution to be provided for each segment.

- Capacity factor – using the above utilisation threshold, the model calculates the amount of the existing network that will require augmentation. The capacity factor defines the amount of additional capacity that is added to the system. For example, if A is the amount of capacity requiring augmentation then the capacity factor multiplied by A is the amount of additional capacity added to the network. As such, the capacity factor must be above zero.

- Augmentation unit cost – The augmentation unit cost is the cost per unit of capacity added to the network.

The augmentation data template allows the DNSP to provide its estimate of these three planning parameters for each segment. The questions below also provide an opportunity for the DNSP to provide relevant supporting explanations to its calculations.

It is worth noting, however, that the AER will also infer the value of these three parameters from historical data provided by the DNSP in the data template – this inference process has been called calibration in recent repex modelling exercises. These inferred planning parameters may be used for comparative purposes along with the DNSP's estimates.

3 Information requests

3.1 Objectives

The objectives of the information requests in this section are to:

- allow for the augex model to be set-up with current asset data and the planning parameters derived by the DNSP
- allow planning parameters to be inferred by the AER from historical data
- provide the opportunity for the DNSP to explain its data, and possible differences in its network from other DNSPs
- allow the benchmarking of augmentation expenditure to be undertaken
- identify network segments (or network groups) that may need further investigation via detailed project or program reviews or other analysis approaches.

3.2 Augmentation data template guidance

The DNSP should populate the augmentation data template with the data indicated. The majority of the data should be self-explanatory to relevant technical staff of the DNSP.

The following provides further guidance to the DNSP.

General

To allow data to be rapidly extracted and analysed from the data template, the DNSP must not alter the structure and location of the tables. Additional sheets can be added if required, but existing sheet names should not be changed.

Asset status data sheets

The asset status sheets collect the data that is used to form the utilisation profiles for each network segment defined in the augex model.

- For sub-transmission lines, sub-transmission and zone substations and HV feeders, each row should represent data for an individual circuit or substation.
- For distribution substations, as it would most likely be too onerous to provide data for individual substations, the DNSP should form substation categories that capture sets of substations. It is anticipated that such categories could be based upon factors, including:
    - pole or ground mounted substations
    - substation ratings
    - the area types supplied (i.e. CBD, urban, rural).

  For each category, the DNSP should calculate the aggregate amount of substation rating in each utilisation band indicated. Where actual maximum demand is not measured at individual substations within a category, it is anticipated that the DNSP will use some algorithm (e.g. based upon customer types and numbers supplied from the substation) to estimate the demand and utilisation.

- For HV feeders:
  - the maximum demand should be that measured at the feeder exit from the associated substation
  - the rating should be based upon the main trunk segment exiting the substation.
- The maximum demand should reflect that used for planning purposes, and as such, should exclude the impacts of abnormal operating conditions.
- The maximum demand annual growth rate should be based upon the most appropriate maximum demand forecast that the DNSP prepares. This information requirement should not be interpreted to imply that a forecast is required to be prepared by the DNSP down the level indicated by the template. For example, if the DNSP only prepares a demand forecast down to a zone substation level then it is acceptable to infer growth rates at a HV feeder level from these forecasts. The approach applied however should reflect the approach the DNSP would take for planning purposes.
- The model segment ID should reflect the relevant segment ID that the DNSP has indicated on the model segment data sheet. The DNSP is provided the opportunity to define the most appropriate model segments. It may be however that the AER will redefine segments based upon the raw asset status data if it considers a different set of segments is more appropriate for comparative purposes.
- As additional guidance on the development of segments, individual segments should be defined to capture differences in the main drivers of augmentations expenditure, such as:
  - growth rates
  - augmentation unit costs
  - utilisation thresholds.

  In forming individual segments however it is important to keep in mind that the model is intended to forecast at an aggregate level, and as such, segments should not be developed to account for specific circumstances. As a general guide, it is anticipated that between 15 and 30 individual segments should be sufficient to model the whole network.

Capex-capacity sheet

The capex-capacity sheet collects the data that is used to assist in inferring planning parameters from the DNSP data.

- Capex in each segment group should be exclusive of corporate/indirect overheads.
- Unmodelled augmentation capex should reflect any capital expenditure that the DNSP is defining as augmentation expenditure for regulatory purposes, but does not consider that it is primarily related to peak demand and utilisation drivers. For example, such expenditure could relate to fault level mitigation projects.

- It is important to stress however that it is anticipated that the large majority of augmentation expenditure would not be considered as unmodelled. As such, if the DNSP considered that not to be the case then this should be discussed with the AER during any preliminary consultation phase (i.e. prior to the lodgement of the regulatory proposal).
- Capex should be reconcilable to overall capex and augmentation capex that may be reported in regulatory accounts and the DNSPs proposal. This request does not require such a reconciliation, but it is assumed that this would be achievable from the information provided in the overall RIN associated with the DNSP's regulatory proposal.
- The type of net capacity added should match the various types of rating indicated on the relevant asset status sheets. For example, for zone substations: type 1 reflects the name plate rating, type 2 reflects the normal cyclic rating, and type 3 reflects the N-1 emergency rating.

Model segment data sheet

The model segment data sheet collects the DNSP's view of the planning parameters for each segment that it considers reflects its forecast augmentation capex.

This sheet captures the model data that is most likely not to be developed by the DNSP as part of its usual practices. As this guidance document does not include a detailed explanation of the augex model, it is assumed that the DNSP would have been provided with some form of tutorial on the augex model to assist in its development of the planning parameters for each segment.

3.3 Supporting information requests

To support the information provided in the augmentation data template and assist in the modelling exercise, the DNSP should address the following questions in a separate document.

1. Maximum demand data – Separately for sub-transmission lines, sub-transmission and zone substations, HV feeders and distribution substations, the DNSP should explain how it has prepared the maximum demand data provided in the asset status sheets. Where relevant, this explanation should include:
    a. how this value relates to the maximum demands that would be used for normal planning purposes
    b. whether it is based upon a measured value, and if so, where the measurement point is and how abnormal operating conditions are allowed for
    c. whether it is estimated, and if so, the basis of this estimation process and how it is validated
    d. the relationship of the values provided and values that could be expected for a 50% and 10% probability of exceedance year.
2. Rating data - Separately for sub-transmission lines, sub-transmission and zone substations, HV feeders and distribution substations, the DNSP should explain how it has determined the rating data provided in the asset status sheets. Where relevant, this explanation should include:
    a. the basis of the calculation of the ratings in that segment, including asset data measured and assumptions made

b. the relationship of these ratings or other ratings with the DNSPs approach to operating and planning the network. For example, if alternative ratings are used to determine the augmentation time, these should be defined and explained.

3. Maximum demand annual growth rate data - Separately for sub-transmission lines, sub-transmission and zone substations, HV feeders and distribution substations, the DNSP should explain how it has determined the growth rate data provided in the asset status sheets. This should clearly indicate how these rates have been derived from maximum demand forecasts or other load forecasts available to the DNSP.

4. Capex - The DNSP should explain the types of cost and activities covered by the capex in the capex-capacity sheet. This explanation should clearly indicate what non-field analysis and management costs (i.e. direct overheads) are included in the capex and what proportion of capex these cost types represent.

5. Actual capex - The DNSP should explain how it has determined and allocated actual capex provided in the capex-capacity sheet to each of the segment groups. This explanation should cover:

    a. the process used, including assumptions, to estimate and allocate expenditure where this has been required

    b. the relationship of internal financial and/or project recording categories to the segment groups and process used.

6. Estimated and forecast capex and capacity - The DNSP should explain how it has determined and allocated estimated/forecast capex and capacity provided in the capex-capacity sheet to each of the segment groups. This explanation should cover:

    a. the relationship of this process to the current project and program plans

    b. any other higher-level analysis and assumptions applied.

    c. Unmodelled augmentation capex - The DNSP should describe the types of projects and programs that it has allocated to the unmodelled augmentation categories. This description should cover:

    d. the proportion of unmodelled augmentation capex due to this project or program type

    e. the primary drivers of this capex, and whether in the DNSP’s view, there is any secondary relationship to peak demand and/or utilisation

    f. whether the outcome of such a project or program, whether intended or not, should be an increase in the capability of the network to supply customer demand at similar service levels, or the improvement in service levels for a similar customer demand level.

7. Network segments – Separately for each network segment that the DNSP has defined in the model segment data sheet, the DNSP should describe the segment, including:

    a. the boundary with other connecting network segments

    b. the main reasoning for the individual segment (e.g. as opposed to forming a more aggregate segment).

8. Utilisation threshold - Separately for each network segment that the DNSP has defined in the model segment data sheet, the DNSP should provide an explanation of the utilisation threshold statistics provided (i.e. the mean and standard deviation). This must cover the following:

    a. the methodology, data sources and assumptions used to derive the parameters

    b. the relationship to internal or external planning criteria that define when an augmentation is required

    c. the relationship to actual historical utilisation at the time that augmentations occurred for that asset category

    d. the DNSP's views on the most appropriate probability distribution to simulate the augmentation needs of that network segment

    e. the process applied to verify that the parameters are a reasonable estimate of utilisation limit for the network segment.

9. Augmentation unit cost and capacity factor - Separately for each network segment that the DNSP has defined in the model segment data sheet, the DNSP should provide an explanation of the augmentation unit cost and capacity factor provided. This must cover the following:

    a. the methodology, data sources and assumptions used to derive the parameters

    b. the relationship of the parameters to actual historical augmentation projects, including the capacity added through those projects and the cost of those projects

    c. the possibility of double-counting in the estimates, and processes applied to ensure that this is appropriately accounted for (e.g. where an individual project may add capacity to various segments)

    d. the process applied to verify that the parameters are a reasonable estimate for the network segment.

10. Comparability between DNSPs – The DNSP should provide an explanation of the significant factors that it considers may result in different augmentation requirements between itself and other NEM DNSPs, faced with similar asset utilisation and peak demand growth. The explanation should clearly differentiate between those factors that may result in differences between:

    - it and other DNSPs in NSW

    - NSW DNSPs and DNSPs in other NEM states.

    In discussing these factors, the explanation should clearly indicate those factors that may impact:

    - the maximum achievable utilisation of assets for the DNSP

    - the likely augmentation project and/or cost.

For each factor discussed, the DNSP should indicate relevant model segments and estimate the impact these factors will have on its augmentation levels and associated capex compared to other DNSPs.

4 AER augmentation tool

This section provides a more functional overview of the augex tool.

This section should be sufficient for a broad familiarisation with the augex tool. For users of the tool, Appendix A provides detailed reference material, including an explanation of the various worksheets within the model, where model inputs and outputs are contained, and how the model is run.

As discussed in Section 3, the augex tool is a high-level model that forecasts augmentation needs (both in terms of additional network capacity needs and associated expenditure) based upon the current utilisation of the DNSP's asset base and forecasts of peak demand growth. The key features of the augex tool are:

- categorising the network to develop a network model
- model inputs and outputs
- augmentation algorithm.

These features are discussed in turn below.

4.1 Categorising the network

4.1.1 Network segments

The augex tool represents a DNSP's network as a set of user-definable network segments. The segments represent the network assets that may be grouped together for assessing augmentation needs. Generally, this means that a segment would represent either a set of substations or lines[3].

This segmentation is required to reflect variations in utilisation thresholds and augmentation costs between different network components. This segmentation can assist both in the accuracy of the model and in its interpretation. In particular, this segmentation can assist when comparing findings between DNSPs.

This form of segmentation is essential to capture variations between broad network types, such as sub-transmission substations and lines, and distribution substations and lines. However, it is often also necessary to capture variations within these network types.

For example, for a zone substation, the maximum utilisation (as a percentage of its total installed capacity) and the type of project that may be suitable when augmentation is required may both be a function of the number of transformers in the existing substation. Therefore, individual segments may be developed, based upon the number of transformers across the population of zone substations.

As the DNSP will be more aware of these differences for its network, individual DNSPs can be given the flexibility of defining the most appropriate set of segments to model their networks.

4.1.2 Grouping

The augex tool requires each segment to be assigned to a more limited set of segment groups. These groups should generally reflect the broader segment types (e.g. zone substations).

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[3] Note the difference here with the repex tool, which defines individual categories at an asset level. As such, it may be expected that the augex tool will have fewer individual network segments than the repex tool will have asset categories.

The aim here is to provide a high-level framework, based upon the segment groups, to aid the analysis and presentation of results.

Individual network segments can be aggregated to 12 separate segment groups. The intention is that the DNSP will suggest the individual network segments in each segment group but the AER will define the groups.

The grouping proposed at this stage is shown in

Table 1. It may be however that the AER will adjust these groups, based upon the input data provided by the DNSPs.

Table 2 Segment groups

Group ID	Group
1	Sub-transmission lines
2	Sub-transmission substations
3	Zone substations
4	HV feeders – CBD
5	HV feeders – urban
6	HV feeders – short rural
7	HV feeders – long rural
8	Distribution substations – CBD
9	Distribution substations – urban
10	Distribution substations – short rural
11	Distribution substations – long rural

4.2 Segment input data

For each network segment in the model, two types of input data are required:

- Asset status data
- Planning parameters.

4.2.1 Asset status data

The asset status data is used to develop the future profile of asset utilisation for that segment. The input data covers the following:

- Asset utilisation profile snapshot – This data set represents a snapshot of the existing profile of asset utilisation for that segment for a particular year. The year of the snapshot represents the starting point for the forecast. Typically, this year will be the last year that actual asset loading information is available. The utilisation profile can be considered a vector, where each element of the vector represents the capacity (in MVA terms) of the assets in that segment at a particular utilisation level. The utilisations range from 0% to 151%, based upon 1% increments.

- Asset utilisation growth rate – For each segment, a growth rate is defined that represents the average annual compound rate of growth in utilisation over the forecast period, assuming the network is not augmented. It is anticipated that this growth rate will reflect the average growth in peak demand that is relevant for the assets contained in that segment.

4.2.2 Planning parameters

- The planning parameter input data is used to forecast the capacity added to the network and the cost of that capacity, based upon the future profiles of asset utilisation for that segment. Three planning parameters are defined for each segment as follows:

- Utilisation threshold – The utilisation threshold defines the utilisation limit when augmentation must occur. As with the repex tool, the augex model uses a probabilistic algorithm to determine the amount of the existing network requiring augmentation. This algorithm assumes a normal distribution for the utilisation threshold. Therefore, two parameters need to be input to define the threshold, namely the:

  - mean utilisation threshold

  - standard deviation of the utilisation threshold.

- Capacity factor – Using the above utilisation threshold, the model calculates the amount of the existing network that will require augmentation. The capacity factor defines the amount of additional capacity that is added to the system. For example, if A is the amount of capacity requiring augmentation then the capacity factor multiplied by A is the amount of additional capacity added to the network. As such, the capacity factor must be greater than zero.

- Augmentation unit cost – The augmentation unit cost is the cost per unit of capacity added to the network. The model uses units of $ per kVA added, which is equivalent to thousands of $ per MVA added.

4.3 Outputs of the Augex tool

The augex tool takes the above inputs and produces the following outputs for the segments and groups.

Utilisation statistics and charts of the input utilisation profile

To aid in the appreciation of the asset base, the model provides summary information of the utilisation profile. This is presented at the segment and segment group level. These outputs provide information, including:

- total volumes and augmentation value
- proportions of the total network above various utilisation levels
- average utilisation and utilisation thresholds, and proportions of aged assets.

The model also provides summary charts of the utilisation profiles.

This type of information is helpful in rapidly understanding the nature of the asset base i.e. its utilisation and value. This information is also helpful when making comparisons of augmentation needs between DNSPs.

Importantly, this information only reflects the utilisation profile as input to the model. It does not account for any forecasts that may be simulated by the model.

20-year augmentation forecasts

Based upon the input data, the model produces year-by-year forecasts of augmentation for the following 20 years.

The forecasts prepared include individual segment forecasts and aggregated group forecasts.

The forecasts cover:

- capacity added (MVA)
- augmentation expenditure ($ millions)
- average utilisation - at the group level, the weighted average utilisation is calculated.

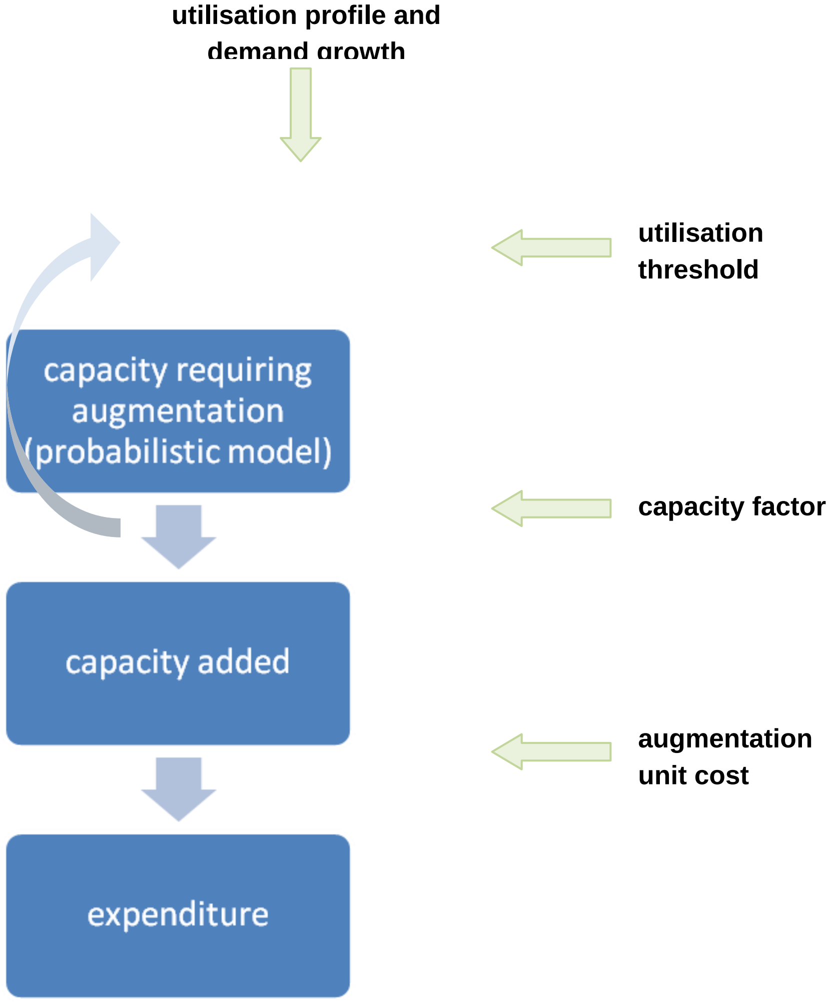
When calculating weighted averages at the asset group level, the total augmentation value of the relevant segment is used for the weighting.

4.4 Augmentation algorithm

The augmentation algorithm is written as a VBA array formula within excel. As such, provided excel is set to have calculations automatically updated, any alterations to inputs should result in the output forecasts being automatically updated. The user is not required to run any macros.

The algorithm produces the 20-year forecast of both capacity added and expenditure for each segment. The figure below shows an overall flow chart of the algorithm.

Figure 1 augmentation algorithm



The three elements of this algorithm are described in turn below.

4.4.1 Capacity to be augmented

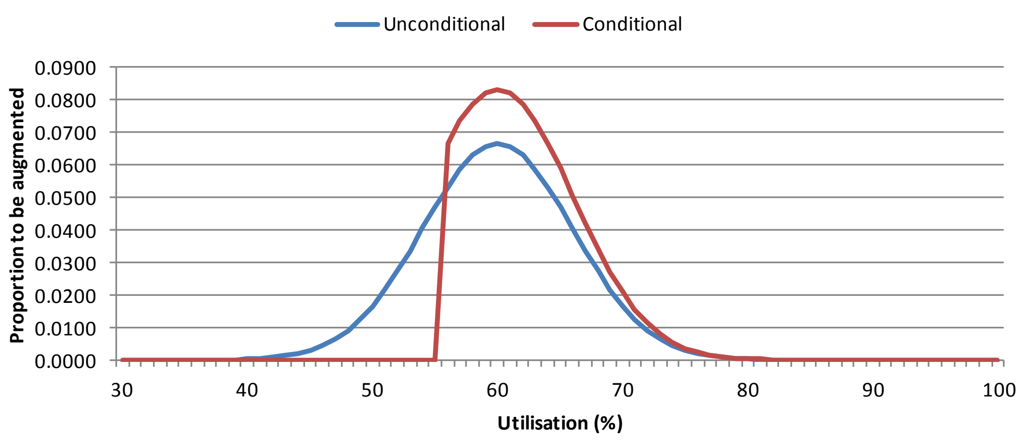
To calculate the amount of the existing capacity that will need to be augmented in each year, the tool uses a similar probabilistic model as applied in the repex tool.

As noted above, the augex tool assumes a normal distribution for the utilisation threshold. For each segment, an "unconditional" probability density function can be generated from the mean and standard deviation, which are provided as inputs.

For any current utilisation level, a "conditional" probability density function can be generated. The "condition" probability density function defines the probability that segment will need to be augmented at a future utilisation level, given it has been loaded to its current utilisation level.

For example, **Figure 2** shows the "unconditional" probability density function for a utilisation threshold. This function represents the probability that an asset will be augmented at a specific utilisation, assuming the average utilisation threshold for this segment is 60% - with a standard deviation of 10%. The figure also shows the "condition" probability density function for a population of assets that are currently at 55%. This condition probability function indicates the proportion of those assets that will need to be augmented as the utilisation increases in the future.

Figure 2 Utilisation threshold probability distributions



To calculate the amount of capacity requiring augmentation in each future year, the tool steps through the following for each utilisation element in the input utilisation profile:

- Step 1 - preparing a conditional probability function from the unconditional parameters, that reflect the utilisation in that element of the utilisation profile
- Step 2 - calculates the year-by-year increase in utilisation, based upon the input demand growth rate
- Step 3 - determine the capacity that must be augmented in each year, based upon the utilisation in that year (from Step 2) and the proportion given by the conditional probability function (from step 1).

4.4.2 Capacity added

The above process calculates the existing capacity that requires augmentation in a given future year. To calculate the capacity that is to be added to the network in that year, the model simply multiplies the capacity requiring augmentation by the input capacity factor:

> Capacity added = capacity requiring augmentation x capacity factor.

As it is feasible that this augmented capacity will also require augmentation later in the simulation period, the augmented capacity is fed back to the probabilistic algorithm above to determine whether additional capacity is required at a later data.

The utilisation for the augmented capacity is defined as:

> New utilisation = demand in the capacity requiring augmentation / (capacity requiring augmentation + capacity added).

The total capacity added following this feedback process is provided as an output of the model.

4.4.3 Expenditure forecast

To calculate the expenditure in a year, the model simply multiplies the total capacity added in that year (i.e. the output of the above calculations) by the augmentation unit cost:

> Expenditure = capacity added x augmentation unit cost.

A Appendix A - Augex model reference manual

This Appendix provides a detailed reference to the augex tool to support the descriptions in the main body of this document. This reference describes the contents of each sheet within the augex tool. The purpose of this appendix is to provide more detailed information that may be relevant to users of the augex tool.

In the descriptions below, the light blue shading indicates that data in these cells is input by the user.

It is important to note that care should be applied when using the tool, as the input of erroneous data or altering the structure may result in unreliable results. This may not be easily identifiable from the outputs.

A.1 Data Input sheets

A.1.1 Sheet name: Tables

This sheet holds the data that is required to initialise the augex model, as follows:

Title	Range	Description
Asset group names	A2:B13	Column B of this table contains the names for each of the 12 segment groups. These names generally represent asset classes, and can be input by the user. The ID in column A represents the number that is input into the appropriate cell in the "Asset data" sheet (see description below).
Now	B17	This parameters represent the year used to develop the utilisation profile. The 1st year of the forecast will be the year after this.

A.2 Sheet name: Asset data

This sheet holds the input data that is required to represent the DNSP's asset base (section 4.2):

Title	Range	Description
ID	A21:205	This parameter is used to define the segment group for the network segment. The ID should be the appropriate number of the asset group defined in the asset group names on the "Tables" sheet.
Segment group	D21:D205	This is the name of the segment group linked to the ID in Column A. This is generated internally by the model.
Network segment	E21:E205	This is the name of the network segment - any name can be chosen by the user.

Title	Range	Description
Unit cost	F21:F205	This is the augmentation unit cost for the segment in $('000) per MVA.
Capacity factor	G21:G205	This is the capacity factor for the segment. This should be a number greater than zero.
MD growth per annum	H21:H205	This is the per annum maximum demand growth rate for the segment. This should be input as a percentage, i.e. 10 represents 10%.
Utilisation threshold	I21:J205	This is the utilisation threshold for the segment. Column I holds the mean life and Column J holds the standard deviation. These should be input as a percentages, i.e. 10 represents 10%.
Aug method	I21:I205	This parameter is used to define the augmentation algorithm applied to generate a forecast at segment level. At this time, only 1 can be used. This represents the probabilistic algorithm, using a normal distribution.
Utilisation profile	L21:FG205	This holds the utilisation profile for each segment, in terms of capacity units (MVA).

A.3 Output sheets

A.3.1 Sheet name: Utilisation profile summary

This sheet provides a summary of the utilisation profile. Rows 6:18 provide summary results at the segment group level. Rows 21:205 provide similar results at the individual segment level.

Title	Range	Description
Capacity	Column F	The total capacity within the segment or segment group.
Unit cost	Column G	The unit cost of the segment - transferred directly from the "Asset data" sheet.
AC (Aug cost)	Column H	The total augmentation cost of the segment or segment group. Calculated as capacity x unit cost, and given in $million.
Prop total	Column I	The proportion as a percentage (calculated by total augmentation cost) of that segment or group to the total augmentation cost of the network.

Title	Range	Description
Rank total	Column J	The ranking of that segment or group (by total augmentation cost) compared to other segments or groups i.e. a ranking of 1 will have the greatest total augmentation cost.
Prop cat	Column K	The proportion as a percentage (calculated by total augmentation cost) of that segment to the total augmentation cost of the associated group.
WARU	Column M	The weighted average remaining utilisation of the segment or group, using the total augmentation cost as the weighting.
WAUuth	Column O	The weighted average utilisation threshold of the segment or group, using the total augmentation cost as the weighting
WAU	Column Q	The weighted average utilisation (as a percentage of the utilisation threshold) of the segment or group, using the total augmentation cost as the weighting.
AC of utilised assets	Columns W:AA	The proportion of assets (by augmentation cost) in 5 bands of utilisation.
Proportion of utilised assets	Columns W:AA	The proportion of assets (by percentage) in 5 bands of utilisation.
Utilisation asset bands	W4:Z4	The parameters used to define the utilisation bands for the above two outputs. These are defined as a proportion of the utilisation threshold.
Group utilisation threshold ranges	AG6:AI17	The range of thresholds in a group: Maximum - column AG Minimum - column AH Average - column AI

A.3.2 Sheet name: aug forecast

This sheet provides the results of the augmentation forecast. Rows 6:18 provide summary results at the group level. Rows 21:205 provide similar results at the individual segment level.

Title	Range	Description
Augmentation capacity added	Columns	Provides the year-by-year forecast over a 20 year

Title	Range	Description
forecast	AY:BR	period of the capacity (MVA) added to the network . Row 19 shows the total capacity added as a percentage of the total capacity of the network.
Weighted average utilisation	Columns BS:CM	Provides the year-by-year forecast over a 20 year period of weighted average utilisation. Row 19 shows the weighted average utilisation of the whole network as a percentage of the weighted average utilisation threshold of the whole network.
Weighted average remaining utilisation	Columns CN:DH	Provides the year-by-year forecast over a 20 year period of weighted average remaining utilisation i.e. the difference between the utilisation threshold and the utilisation. Row 19 shows the weighted average remaining utilisation of the whole network as a percentage of the weighted average utilisation threshold of the whole network.
Replacement quantity forecast	Columns DI:EB	Provides the year-by-year forecast over a 20 year period of the augmentation capex ($millions). Row 19 shows the total augmentation capex as a percentage of the total augmentation value of the network.

A.4 Chart sheets

A.4.1 Chart sheet name: utilisation profile chart

This chart sheet provides two charts - one stacked and one unstacked - of the utilisation profile at the segment group level:

A.4.2 Chart sheet name: Forecast Ch1

This chart sheet provides three charts of the augmentation forecasts:

- The stacked bar chart at the group level, showing the year-by-year augmentation expenditure forecast ($ millions).
- An z-y plot, showing the forecast weighted average utilisation for each group and the weighted average utilisation of the total network.
- The un-stacked bar chart at the group level, showing the year-by-year augmentation expenditure forecast ($ millions).

A.4.3 Chart sheet name: Forecast Ch2

This chart sheet provides one chart of the augmentation expenditure forecast for each group, represented as a 3-dimensional bar chart showing.

A.5 Internal sheets

The model also includes three other sheets that are used for internal purposes i.e. producing charts and aiding with the calculations. These sheets are called:

- Utilisation profile (Inst)
- Utilisation profile (RL)
- Utilisation profile

These three sheets have the same structure, and as the names suggest, are used to hold different representations of the utilisation profile. The user is not required to interact with these sheets, and as such, they are not described in detail here.

A.6 Macros and setting up a model

When setting up a model of an DNSP using the augex tool, the following process should be followed:

1. Set the required initialisation data in Sheet: Tables (i.e. group names, starting year)
2. Input segment data in Sheet: Asset data. Blank rows can be left between asset categories to help with the visualisation. However, the following two point are important:
   a. segments should not be placed below the coloured table
   b. rows (or columns) should not be inserted or deleted.
3. The macro "initcalcs" should be run. This macro calculates the number of segments being used and automatically sets up other calculation sheets.

The model should now be able to produce augmentation forecasts. Note however, if additional segments are added below the final segment on the asset data sheet, then the macro "initcalcs" should be run once again.

Additional sheets can be added as required; for example, to contain working calculations and comments. A sheet called “Notes” is also included for these purposes.