2018-22
POWERLINK QUEENSLAND REVENUE PROPOSAL

APPENDIX 5.04

Nuttall Consulting
Forecasting Methodology Review

Delivering better value

Nuttall Consulting

Regulation and business strategy

Forecasting methodology review

Non-demand driven capex top-down method

A report to Powerlink

Confidential final

9 November 2015

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Executive Summary

Introduction

Nuttall consulting has been engaged by Powerlink to review the “top-down” forecasting methodologies, which it has used for elements of its non-demand-driven capital expenditure (capex) forecast. These forecasts will form part of Powerlink’s capex forecast in its next regulatory proposal to the Australian Energy Regulator (AER). The methodologies under review are:

- the **AER repex model**, which has been used for a large part of Powerlink’s age/condition-driven replacement capex
- a **base-step-trend method**, which has been used for other elements of Powerlink’s non-demand-driven capex.

To undertake this review I have reviewed relevant Powerlink draft documentation and models, conducted a two-day workshop with relevant Powerlink personnel, conducted numerous additional follow-up emails exchanges and telephone meetings, requested and received a response to a series of questions, and conducted my own indicative modelling and analysis to test various matters.

Review findings

I consider the AER repex model and base-step-trend approaches to be appropriate methods for preparing the capex forecast for the relevant capex categories, for these regulatory purposes. Further, to a very large extent, I consider that Powerlink has set up and implemented these approaches appropriately.

I do however have some concerns with the modelling. Many of these are fairly minor, but a number could have the potential to alter the forecast in a significant way.

The repex model

I consider the repex model to be an appropriate method for preparing the replacement forecast for many asset classes, for these regulatory purposes:

- I do not consider that alternatives, based on more complex detailed engineering analysis, are clearly a better method for forecasting replacement capex for these purposes
- the AER repex model (or similar) with suitable application can address some of the potential accuracy shortcomings of the detailed engineering analysis, when preparing forecasts for regulatory purposes
- forecasting through the AER repex model should reduce the effort associated with conducting the revenue reset process – both for the NSP and the AER
- I see no clear reason why the adoption of this method over detailed engineering analysis would hinder the AER’s assessment process

- Powerlink has advised that it has processes in place to ensure the forecast produced by the model does not contradict the asset management plans it has developed through its engineering analysis.

To a very large extent, I consider that Powerlink has set up and implemented its repex models appropriately. In this regard, in most cases, the asset categorisation in the model and the method it has applied to calibrate the lives is appropriate, and is broadly in accordance with the approach the AER has applied to prepare an intra-company (i.e. business-as-usual) benchmark forecast (for replacement volumes).

There are some differences in how Powerlink has applied the model, but I agree with Powerlink that these can be characterised as “enhancements” as they should improve the accuracy of the forecast. Most notably:

- additional asset categories have been added to better capture variations in asset lives and unit costs, and in turn improve the accuracy of the model forecast
- assets have been removed that are forecast through Powerlink’s “bottom-up” methodology or are planned to be decommissioned
- a repex model using 2009 age profiles has been used to more accurately calibrate the asset lives to replacement outcomes that have occurred between 2008/09 and 2013/14
- adjustments have been applied to RIN data (age profiles and historical replacement volumes) to account for reporting discrepancies and adjust the data to make it more applicable to the repex model.

I have two significant concerns related to the modelling of towers and the secondary systems, which together represent a large portion of the repex forecast produced by the model.

- For towers, I am concerned that Powerlink’s approach to deriving the tower lives is resulting in lives for some towers, which are not supported by the input data. Importantly, my indicative analysis of the data through the model suggests that the lives Powerlink is deriving are shorter than the lives it has achieved in recent history for towers in low corrosion zones.
- In the case of secondary systems, I am concerned that asset age profiles that form an input to the modelling process suggest that the model may not be set up correctly or there is an issue with the age profile that means it is not suitable for use in the repex model.

The above two concerns have the potential to result in significant changes to the forecast. However, they will act in opposite directions: the forecast for towers will reduce but the forecast for secondary systems will increase.

In addition to the above, I have found the following issues that may have a smaller effect on the forecast:

- In addition to the possible issue with the secondary system age profiles noted above, this review has also found possible issues in other age profiles.
- The modelling of current transformers associated with dead-tanks circuit breaker is most likely incorrect.

It is important to stress that I am not recommending that these concerns mean that the forecast is incorrect and must be changed. But these matters should be investigated further to determine whether errors can be corrected and the model revised. If the model still conflicts with Powerlink's expectations then relevant assumptions should be robustly supported by asset management information. For example, for tower, if the existing life assumptions are considered correct then Powerlink will need to ensure it has supporting data and analysis to justify these assumptions.

I have also noted a number of other matters through this review that Powerlink may wish to consider further:

- Given the issues with the accuracy of a number of age profiles, Powerlink could consider implementing some form of audit process to provide a level of assurance that these age profiles and historical replacement volume data are accurate and fit for purposes. It is assumed that this could be built into the audit processes that are already defined for the data reported in the RIN.
- The unit costs in the model reflect Powerlink's estimates of their forecast unit costs. I am unable to say whether these unit costs are above or below Powerlink's historical costs (as could be derived through the RIN data). This is likely to be a consideration of the AER, and so, Powerlink may need to investigate whether it can demonstrate this matter.
- I note that Powerlink has used 6 years of historical data to calibrate the lives. This differ from the approach the AER has applied recently, where it has used 5 years. This assumption of Powerlink's is not necessarily incorrect, but Powerlink may need to examine the effect of using a 5-year period and if it results in a significantly different forecast it may need to justify its reasoning for adopting the 6-year period.
- The AER is likely to have limited time to review these models and supporting documentation. It is highly unlikely it will engage with Powerlink to the extent I have in this review to address matters it does not understand sufficiently. Therefore, it will be critical that the final models and documents are presented as clearly and simply as possible. In addition, ideally, workbooks should be produced that clearly show the reconciliation between age profiles and replacement volumes used or forecast in the model, and those provided in the relevant RIN tables.

Base-step-trend method

I consider the base-step-trend method to be an appropriate approach for preparing the forecast for the non-demand-driven capex categories, elected by Powerlink. Further, to a very large extent, I consider that Powerlink has implemented this approach appropriately. Importantly, the categories represent only a small portion of non-demand-driven capex and so a simplified approach should be suitable; and this approach is similar to what the other NSPs and the AER has used to prepare forecasts for these types of category.

My main concern with Powerlink's implementation of the base-step-trend method relates to its application in the security and compliance capex category. The historical baseline capex for this category shows a very significant spike in 2011/12 after exclusions have been applied. This spike is due to two large programs of works that have been split into smaller projects. This may suggest that these programs should also have been excluded when preparing the baseline capex.

If these programs are excluded then the historical baseline looks more uniform and the resulting trend forward is much lower. That said, it is not clear whether the exclusion of these programs to prepare the baseline would require a countervailing change to the forecast by adding similar planned programs as step changes.

In addition to the above, I have concerns with the following two matters, which are less significant on the resulting forecast:

- I consider the historical average may be a more appropriate trend assumption for the security and compliance category, rather than a linear trend - unless Powerlink has a compelling argument for the suitability of the linear trend.
- For the other network capex category, a project is added as a step change (the fault locating system project), but earlier stages of this project are not removed to produce the base.

Powerlink will need to consider these matters further and decide whether an alteration to its forecast is necessary.

It is worth noting that Powerlink has advised that it is difficult to reconcile the historical costs used to produce this forecast with expenditure reported in the category analysis RINs. I consider it would be reasonable for the AER to require some form of assurance that the costs have been allocated correctly to apply the base-step-trend method to ensure costs are not being double counted (at least party) through other forecasting methods. Therefore, Powerlink may need to consider whether it is feasible to conduct some form of audit of a sample of the projects in each category to provide a level of assurance that they have been allocated correctly, and they do not contain activities/costs that are being forecast elsewhere. Ideally, this would be supported by also providing some clear reconciliation of these costs to the category analysis RIN – or vice versa.

Closing

It is important to stress that a positive finding here, or corrections to address the matters raised, does not necessarily mean that the *forecast* is appropriate. The AER will undertake a range of assessment approaches to arrive at this view. This form of methodology review is only one component of such an assessment.

Importantly, this review has focused on the suitability of the methods to produce a form of intra-company benchmark. That is, assuming historical practices represent prudent and efficient decisions and using these as the basis for the forecast.

This review has not considered whether this underlying assumption is valid, which relates to inter-company benchmarking approaches. Should Powerlink consider that this assumption is not valid then it may need to apply some form of adjustment to the forecasts produced through these methods.

1 Introduction

1.1 Background

Powerlink is preparing a revenue proposal to cover the period 2017/18 to 2021/22, which must be submitted to the Australian Energy Regulator (AER) by 31 January 2016. This proposal must include (among other things) a capital expenditure (capex) forecasts to cover this period.

Powerlink has advised the AER that it will use a range of **bottom-up** and **top-down** forecasting techniques to prepare the forecast for its **non-demand driven capex**. Importantly, Powerlink considers that the top-down techniques are adaptations of some of the techniques the AER will use to assess Powerlink's capex forecast. Most notably, Powerlink has indicated that it will use the **AER repex model** to prepare a forecast a large part of its replacement capex (repex).

There has already been some engagement with the AER and other stakeholders on this approach through the AER's "framework and approach" stage of the Powerlink determination. Through this process, some stakeholders have raised concerns with Powerlink's use of top-down forecasting techniques for this purpose. Although the AER has stated that it "*continue(s) to expect that the major technique used in forecasting capex will be the "bottom–up build*", its final framework and approach decision suggests it is not against Powerlink using top down techniques.

The AER has however noted that Powerlink faces some risk of its proposal being rejected and its capex forecast being amended if the AER considers the forecasting to be inappropriate. An important matter here appears to be that Powerlink's use of top-down techniques should not hinder the AER's ability to apply the suite of assessment techniques the AER has defined in its Expenditure Forecast Assessment Guideline (EFA Guideline).

1.2 Terms of reference

Powerlink has engaged Nuttall Consulting to perform a methodology review on the top-down methods Powerlink is using to prepare the forecasts for its non-demand driven capex.

This engagement should:

- review the various capex forecasting models that Powerlink has developed
- advise on the suitability and robustness of these models for forecasting capex to meet the capital expenditure objectives in the National Electricity Rules (Rules)
- advise on the appropriate probability distribution to be applied to each of the major asset categories
- advise on enhancements to the models that may be required in order that the forecasts produced by models meet the capital expenditure objectives

- advise on any other matters contained in the AER's Expenditure Forecast Assessment Guideline (EFA Guideline) that should be taken into account
- prepare a report on the review, suitable to be used as a supporting document to the regulatory proposal

This document represents the report indicated in the last dot above.

1.2.1 Caveats on this review

The following points are very important in appreciating the limitations of this review and its findings.

- The focus of this review is on the methodology, not the forecast. As such, positive or negative views on the methodology do not necessarily mean that the forecast is or is not appropriate. A methodology review such as this is only one of the many assessment techniques the AER will apply to assess the capex forecast.
- The methodology Powerlink has used to generate unit cost estimates, which form an input to the repex model, is outside the scope of this review. Similarly, this review has not considered the method and assumptions used to transform between nominal and real costs, or forecast cost escalations.
- The scope does not include any form of audit of the underlying input data that is driving the models. The review *does* provide some level of negative assurance on data in that the approaches to produce the data have been discussed and data has been examined. But nothing in this report should be taken as an assurance that data is correct.
- This review has not reviewed in any way Powerlink's asset management and governance practices, its asset management plans, or the analysis and data used to prepare bottom-up plans.

Finally, it is important to stress that this review is largely focusing on the suitability of the methods to produce a form of intra-company benchmark (or business-as-usual forecast). That is, assuming historical practices represented prudent and efficient decisions and using this assumption as the basis for the forecast.

This review has not considered whether this underlying assumption is valid, which relates to inter-company benchmarking considerations that rely on other assessment methods out of the scope of this review. Should Powerlink consider that this assumption is not valid then it may need to apply some form of adjustment to the forecast produced through the methods assessed here.

1.3 Review approach

The review approach has involved the following:

- a review of Powerlink draft documentation, included:
  - repex model files

  - the base step trend model
  - methodology explanations
  - various input data files.
- a two-day workshop with key Powerlink personnel responsible for developing and preparing the forecasts and documents.
- the provision and response to an information requests (Information request #1)[1]
- numerous informal queries and clarifications, covered by various telephone discussions and emails exchanges
- analysis and modelling to investigate the models and forecast, discussed in more detail in the review sections of this report.

In appreciating this review approach, it is important to note that the forecasts and supporting documents are still work-in-progress. Therefore, this review has been conducted with drafts of models and methodology explanations that represent Powerlink's position at a point in time, prior to the finalising of the forecast.

With this in mind, should the forecast or methodology change significantly than any findings may need to be re-examined to confirm their ongoing validity.

1.4 Structure

This report is structured as follows:

- In section 2 I will provide a brief overview of Powerlink's forecasting methodologies and the resulting forecast. The section is included to provide context to the reader and highlight key matters that I have considered through the review.
- Section 3 discusses my review of Powerlink's application of the AER repex model, including my findings
- My review and findings of Powerlink's base-step-trend capex forecasting method are discussed in Section 4.

It is important to note that in all sections I will set out my appreciation of Powerlink's methodology. These section are there solely for Powerlink to confirm that I have understood its methodology sufficiently. Nothing in these "appreciation" sections should be interpreted as my acceptance or otherwise of the appropriateness of the methodology.

[1] The information request was made in an email, dated 17/9/15, and the final response provided in an email, dated 2/10/15

2 Powerlink's forecasting methodology

In this section I provide a brief overview of the Powerlink forecasting methods covered by this review, indicating:

- the broad methodological approaches
- the capex categories (by asset class, driver and activity) covered by the forecasting methods
- the draft forecast (over the next regulatory period) compared to historical levels.

The purpose of this section is to highlight some of the key matters that provide context to my review and its findings, which are discussed further in the following chapters.

2.1 Powerlink's forecast methods and capex categories

This review is focused on three elements of Powerlink's non-demand driven capex forecast:

- age-related replacement capex
- security and compliance capex and
- other network capex.

2.1.1 Age-related replacement capex

Age-related replacement capex covers the capitalised replacement (or life extension) of aged assets. The replacement activities in this category are driven by age-related factors, such as the assets condition and their age-related technical/financial performance.

Powerlink uses three different methods to produce the forecasts for this capex category:

- **The AER repex model**

  The AER repex model has been developed to produce the age-related replacement forecast for a range of asset classes, covering:

  - towers (i.e. the structures carrying the overhead conductors)
  - overhead conductors
  - switchgear, including instrument current transformers (CTs) and voltage transformers (VTs)
  - secondary systems, including substation protection schemes, telecommunication systems and metering

- buildings and site infrastructure.

Within the model, these asset classes are typically built up from a number of individual asset categories. The model produces individual forecasts at this asset category level.

It is worth noting that the model includes other asset classes that form the overall network. However, where these needs are forecast through Powerlink's other methodologies or Powerlink is not anticipating the need to replace these asset over the next regulatory period, the model parameters have been set to ensure forecasts are not produced.

- **Detailed engineering assessment** (Powerlink's "bottom-up" methodology)

  A number of specific planned projects have been forecast using Powerlink's detailed engineering assessments. This methodology is not within the scope of this review; however, it is understood that this method covers a limited number of specific projects that Powerlink considers are less suitable for top down (repex model or base-step-trend) methodologies.

- **Base-step-trend method**

  Powerlink has advised that there are a range of works that are allocated to the age-related replacement capex category, but are not captured by the two approaches above. This includes a range of project types, typically associated with Powerlink's SCADA and telecommunications facilities, but not covered by the asset categories in its repex model.

  Powerlink has used a form of the "base-step-trend" method to prepare the forecast for this element of the age-related replacement forecast, which I will call non-modelled repex in this report.

2.1.2 Other network capex and security and compliance capex

The other elements of Powerlink's forecasting methodology covered by the review include:

- security and compliance capex, which can be asset replacements or asset additions driven by physical security and power quality monitoring needs
- other network capex, which represents a balancing item for the AER's capex categories, covering miscellaneous activities that are not allocated elsewhere, such as the purchase of system spares and deployment of new technology.

Powerlink has used a form of the "base-step-trend" method to prepare the forecasts for these two capex categories.

2.2 Overview of forecasts

Table 1 below summarises the asset groups and activities covered by the two forecasting methods covered by this review. More importantly, this table also provides the forecast produced by this method compared to the recent actual levels. This analysis provides important context to the review discussed in the following chapters, and has been used to identify potential matters that need to be examined by this review.

For the repex model, this comparison is provided for average per annum replacement volumes. For the base-step-trend method, only the capex comparison is provided as this method does not produce a volume forecast.

The columns to the right provide important measures, namely:

- the percentage change (in volumes or capex) from history to forecast (i.e. a change that may need to be explained through this review)[2]
- a qualitative indication of the relative significance of the forecast as a proportion of the total capex under review[3].

The key points to note from this table are as follows.

- Both methods are predicting material reductions in capex from historical levels.

  This position is in stark contrast to most reviews I have undertaken for regulators, where typically non-demand capex has been forecast by the NSP to be increasing from historical levels.

  This forecast reduction is an important point when considering the appropriateness of the methodology compared to other methods, such as detailed engineering assessments. I will touch upon this matters further in the next two chapters when I discuss the methods used by Powerlink in the context of concerns raised by some stakeholders in the use of such top-down approaches.

- The component of Powerlink's forecast prepared by the repex model cover the most significant portion of the capex under review. The draft models provided indicate that this will be in the order of 80-90%.

  This accords with Powerlink's guidance at the outset of this review that the repex model was the primary focus of this review.

- Although, in total, capex is forecast by the repex model to reduce from historical levels, this table highlights a number of significant matters that have been important considerations for this review in guiding where I have focused my effort:

  - The towers asset group represents the most significant asset category in the repex model. It covers the greatest proportion of capex (in the draft models under review), which is also forecast to increase significantly from historical levels. Also of note is the large change between predominantly tower replacement activities historically compared to the lower unit cost refit (life extension) activities in the forecast.

[2] For the repex model, the percentage change for asset groups and in total is a weighted average estimate, using the draft forecast capex indicated in the models to weight the contribution from the asset categories in that group. This is not an accurate calculation and so should be seen as a guide only.

[3] This has been determined from the draft capex forecasts indicated in draft models provided for this review.

- The secondary systems asset group is the second most significant group. The substation protection/control scheme category is by far the most significant in that group. However, in contrast to the towers, this category is forecast to be reducing very significantly from historical levels. On the other hand, the replacements in the telecommunications category are forecast to increase substantially.
- The switchgear asset group has only a moderate relative significance, in terms of the scale of the forecast. Furthermore, replacements in this asset group are forecast to be reducing significantly from historical levels.
- The buildings asset group is less significant. However, there is a noticeable increase in replacements from historical levels.

The changes highlighted above and their reasons are clearly important for this review and will be discussed further in Chapter 3.

The forecast in the conductors group is largely immaterial. In the draft model provided for this review, the forecast is prepare based upon an assumed life of 80 years because the replacement of conductors due to the condition of the conductor was very low. Most conductor replacement was due to other reasons. During the course of this review, Powerlink has advised that it intends to use an historical volume of conductor replacement to calibrate the life and produce the forecast[4]. I understand that this volume will be low and as such anticipate that the forecast will still be immaterial. Therefore, I have not considered the modelling of conductors in this review.

Should the conductor forecast be more material or show a significant increase from the historical volumes then Powerlink may need to reconsider its approach and whether it can justify the forecast through the repex model. For example, if it cannot be clearly shown that conductor replacement should increase then a base-step-trend approach, using historical costs may be more appropriate.

- The base-step-trend method has only covered a small percentage of the forecast covered by the review. Nonetheless, the table still indicates a number of important points to guide this review.
  - Security and compliance is the largest category covered by this forecasting method, representing 41% of the base-step trend forecast. It is also the only category where the base-step-trend method is predicting an increase from historical levels.
  - Both the non-repex modelled replacements and the other network capex categories show significant reductions (26%) from historical levels.

  Clearly, in the context of a base-step-trend approach, the reasons for these changes will be important considerations for this review.

[4] Advised in response to question 5 of the Information Request #1

2.3 Summary of key points for this review

Based upon the above, key issues for this review are the modelling factors driving the changes predicted by the methods and whether these changes could simply be a modelling error.

The review encompasses all the (in-scope) capex categories to some degree. However, the most significant categories for this review are:

- the tower and secondary systems asset groups in the repex model
- security and compliance capex category in base-step-trend model.

Table 1 Forecasting method summary and forecast comparison

Forecast Method	Asset group	sub-group	Average per annum: activity volumes History 2008/09 - 13/14	activity volumes Forecast 2017/18-21/22	Capex ($ millions)[a] History 2008/09 - 13/14	Capex ($ millions)[a] Forecast 2017/18-21/22	Forecast measure % change[b]	Forecast measure capex significance
AER repex model	Towers	*Towers Replaced*	*120*	*8*	capex not applicable		*-93%*	*High*
		Towers Refit	*12*	*218*			*1666%*	
		Tower - all	**133**	**226**			***27%***	
	OH conductors		**0**	**1**			**na**	Immaterial
	Switchgear	*Switchgear – CB*	*26*	*15*			*-40%*	*Moderate*
		Switchgear – switches	*109*	*83*			*-24%*	
		Switchgear – VT	*49*	*31*			*-37%*	
		Switchgear – CT	*54*	*30*			*-45%*	
		Switchgear - all	**238**	**159**			***-37%***	
	Secondary	*substation protection/control schemes*	*63*	*28*			*-55%*	*High*
		Telecommunications	*69*	*106*			*53%*	
		Metering	*10*	*6*			*-38%*	
		Secondary - all	**142**	**140**			***-50%***	
	Buildings and infrastructure	*Buildings*	*8*	*7*			*-13%*	*Low*
		Site Infrastructure	*2*	*3*			*58%*	
		Buildings/Infrastructure - all	**10**	**10**			***17%***	
	Total repex model		**522**	**534**			***-25%***	
Base-Step-Trend		non-repex model replacement	volumes not applicable		$5.0	$3.7	-26%	Moderate
		security / compliance			$6.9	$7.1	2%	
		other			$9.0	$6.7	-26%	
	Total base-step-trend				**$20.9**	**$17.4**	**-17%**	

a – the capex figures should be treated as indicative only, as there could be some inconsistency between nominal and real dollars.

b – the percentage change for the repex model asset groups and total is a weighted average estimate, using the draft forecast capex to weight the contribution from the asset categories in that group.

3 Review of AER repex model method

In this section I discuss my review of Powerlink's use of the AER repex model.

To provide context to this discussion, I first provide an overview of the AER repex model.

I then set out my appreciation of Powerlink's application of this model, in conceptual terms, and discuss the appropriateness of this approach for preparing regulator forecasts. I also draw similarities and differences to how the AER has used this model to assess replacement forecasts.

Following this, I provide more detail of how Powerlink has approached the modelling of the various asset classes covered by the model. I discuss the appropriateness of this, including my views on the significant changes I highlighted in the preceding Chapter.

The section concludes with a summary of the key findings of this component of my review.

3.1 AER repex model

The AER repex model is a form of predictive model, which allows for key drivers of replacement, namely the age of assets and their economic life. It is critical to understand that the model is not assuming in any way that a strict age-based replacement strategy is applied. Rather, a relationship can be drawn between the age of an asset and when it is replaced (or its life extended).

The network is represented as asset categories, which typically should represent physical assets. These categories should be defined to reflect the different lives and/or unit costs.

Each asset category is represented in the model by its age profiles (i.e. the volume of assets at different ages), its assumed asset life and replacement (or life extension) unit cost.

The replacement prediction algorithm assumes the replacement life of an asset can be represented by a probability distribution, which defines the probability that an asset will be replaced at any particular age. This uses similar "survivor" theory used in mortality and reliability modelling.

Parameter **calibration** is the term the AER use (and Nuttall Consulting has used) when setting asset live or unit cost parameters to reflect a defined outcome. Typically, this is used to set the parameters to reflect recent historical outcomes. For example, determining the asset life to ensure that the model predicts the equivalent replacement volumes that have actually occurred. In this way the forecast produced by such a calibrated model reflects a business-as-usual forecast. This forecast can be used as a type of intra-company benchmark forecast.

I will discuss more on how the AER has applied the model below in when discussing my review of Powerlink's application of this model.

3.2 Powerlink's application of the AER repex model

3.2.1 Appreciation of AER repex modelling approach

As discussed in Chapter 2, Powerlink has used the AER's repex model to prepare the forecast for the following asset groups:

- Towers
- Overhead conductors
- Switchgears
- Secondary systems and telecommunications
- Buildings and site infrastructure.

The repex modelling approach adopted by Powerlink uses two AER repex models, which are set up differently:

- **forecast model** - one model is set up and used to produce the forecast from 2014/15 to 2021/22 and beyond
- **calibration model** - a different model is used to calibrate the asset lives that reflect recent history.

These two models are explained further below.

The forecast model

The following summarises my understanding of the key features of Powerlink's forecasting model:

- Asset categorisation
  - Asset categories for each asset group are defined by Powerlink to reflect expected differences in asset lives and unit cost. The categories are very similar to the AER RIN categories (table 5.2.1 of the category analysis RIN). I will discuss these categories in more detail when discussing the asset group modelling below.
- Asset category age profiles
  - The model uses age profiles that define the status of the network in 2013/14. That is, the first year of the forecast is 2014/15.

    These age profiles are generated from the same asset data systems Powerlink has used to generate the age profiles reported in its RIN (table 5.2.1 of the category analysis RIN). However, it has made a number of alterations to these age profiles and the process it uses to prepare them, which it believes makes them more suitable for use in the repex model.

The first is to account for the assets that will be replaced through its bottom-up forecast. As noted in Chapter 2, Powerlink has used a bottom-up method to develop elements of its replacement forecast. This method is outside the scope of this review. However, it is important to note that some of the planned projects determined through this bottom-up method involve the replacement of assets covered by the repex model. To avoid double counting, Powerlink has removed these assets from the relevant 2014 age profiles.

The second concerns assets that have been identified as not requiring replacement when they reach the end of their life. Powerlink has removed these assets from its age profiles to ensure that the model does not predict the need (and capex) to replace these.

- Asset lives
  - Asset lives are largely based upon the lives deduced through the calibration model. There are additional assumptions however to defined asset lives for some asset categories. These assumptions are specific to the asset group being modelled, and therefore, I will discuss them further when discussing the asset group modelling.
  - The asset life probabilistic model uses the model’s inbuilt normal distribution assumption in all cases. Powerlink also assumes that the standard deviation of each asset life is the square root of the mean life.
- Asset unit costs
  - Powerlink uses its forecast unit cost estimates, which have been developed for each asset category. I understand that this set of unit costs have been prepared separately (from the repex modelling exercise).

    These unit costs and the methodology Powerlink has used to derive them is outside of the scope of this review. Therefore I will not comment here on whether there are reasonable or not. However, I will discuss below their use in the repex model in the context of how the AER may apply the model (and Nuttall Consulting has applied the model previously) to generate a repex forecast.

The forecast model also include additional calculations to allow for cost escalation (above CPI) and to transform between nominal and real costs. These calculations are outside the scope of this review, and I will not discuss them further.

Finally, it is worth noting that when producing the final forecast, Powerlink substitutes in any "approved” capex (i.e. capex approved through its internal planning and governance process) in circumstances where this approved capex is already above the repex model forecast. This assessment is conducted at the asset group level and it is understood that this adjustment only affects the first two years of the forecast (2014/15 and 2015/16), and so does not cover the forecast over the next regulatory period.

The calibration model

As noted above, the calibration model's sole purpose is to generate the asset lives that are used by the forecast model. In line with the calibration process noted above, it calculates these lives to ensure that the replacement volumes forecast by the model reflects recent historical replacement levels.

The following summarises my understanding of the key features of Powerlink's calibration model and calibration method:

- Asset categorisation
  - The asset groups are similar to the forecast model. However, the asset categories in many groups have been altered to aid the calibration process. In this regard, Powerlink has typically aggregated multiple asset categories to produce a single asset category for calibration purposes.

    Powerlink has done this in circumstance were it believes the lives should be similar across categories. For example, across voltages for towers and switchgear. This has provided larger asset populations and replacement volumes for calibration purposes, which Powerlink considers should improve the accuracy of the calibration process.

    I will discuss these categories in more detail when discussing the asset group modelling below.
- Asset category age profiles
  - The model uses asset age profiles based upon the status of the network in 2008/09. These profiles are generated from the same data systems used to prepare the 2013/14 profiles.

    It is understood that the process applied by Powerlink to generate the 2008/09 age profiles starts with the same data system used to prepare the 2013/14 profile. The event logs of the asset data system are interrogated to "roll-back" the specific changes to Powerlink's asset base that have occurred since 2008/09.

    Changes due to the transfer into Powerlink's asset base of the aged asset of other parties (e.g. Queensland distribution businesses), which have occurred over this period, have been identified and not removed through this process. This adjustment has been applied because these assets strictly would not be included in the 2008/09 profile, but could have required replacement by Powerlink because of their age following their transfer.
- Asset life calibration assumptions and process
  - The model is set up with the equivalent life probability model used by the forecast model, namely using the model's normally distributed life model and assuming the standard deviation is the square root of the mean life. In this way, the calibration process only has to determine the mean life for each asset category.

These asset category mean lives are set to ensure that the average per annum replacement volumes that are forecast by the model over the 5-year period from 2009/10 to 2013/14 equals the average per annum actual replacement volumes over the 6-year period from 2008/09 to 2013/14.

The actual replacement volumes over this period are developed from volumes reported in the category analysis RIN (table 2.2.1). However, Powerlink has performed a number of alterations to these volumes, which it believes improve the accuracy of the calibration process. These alterations are specific to the asset categories, and therefore, I will discuss these adjustments further when discussing the asset group modelling below.

3.3 Review discussion – general points

My considerations of Powerlink's application of the AER repex model to prepare its replacement forecast can be viewed in terms of the following three key matters:

- the **suitability of the approach** (in a general sense) as a method to prepare a component of the replacement capex forecast, which forms part of its regulatory proposal
- the **set-up of the forecasting model**, covering how Powerlink has represented its network in the model in order for the model to produce a forecast
- the **setting of the planning parameters** in the model in order for the model to produce a forecast.

These three matters will be discussed in turn in the three sub-sections below.

3.3.1 Suitability of approach

Before turning to my views on the suitability of using the AER repex model (or a similar method), it helpful to re-state what the capex forecasting methodology is trying to represent. This is defined by the Rules[5]:

- Capex objective – The objective of the forecast is to maintain reliability, safety and security (in aggregate) and comply with obligations. For the purposes here, this could be simply viewed as the objective to maintain the risk position of the NSP.
- Capex criteria – The forecast should reflect the prudent and efficient expenditure to achieve this objective, which for the purposes of this review is also the prudent and efficient volume to achieve that objective.

In deciding on a suitable forecasting methodology, it is important to balance the effort associated with the methodology with its accuracy. Furthermore, when considering effort, it is important to factor in the effort (resource) to produce the documentation necessary to satisfy a regulatory review.

[5] 6A.6.7, National Electricity Rules

In addressing these competing factors, there will always be advantages and disadvantages with any forecasting methodology. I note that a concern raised by some stakeholders during Powerlink's framework and approach stage is whether a "bottom-up" method is more appropriate[6]. Here I am assuming that "bottom-up" in this context means an approach that relies on detailed engineering analysis (DEA), similar to what the NSP may apply in its business-as-usual asset management planning practices.

On balance, I see no fundamental reason why the AER repex model (or similar method) is not an appropriate basis for a large part of an NSPs repex forecast in its regulatory proposal to the AER.

A number of considerations lead to this view.

First, I do not believe that DEA is clearly a better method for forecasting replacement capex.

For regulatory purposes, I am not aware of the empirical evidence that DEA produces a more accurate forecast for these regulatory purposes.

A DEA forecasting methodology has significant scope to overstate the aggregate needs when developing forecasts for regulatory purposes. DEA (e.g. actual asset replacements and associated expenditure) produces a prudent and efficient outcome because of the natural tension this forecasting method has with the business's governance processes[7]. Any business is likely to have a large pipeline of planned projects/programs resulting solely from its DEA processes, which will be in various stages of analysis, planning, challenge and approval through the governance processes. This pipeline is always likely to be greater than what will occur[8]. The regulatory proposal process can impose a relaxation of that internal tension as it is difficult to build the effect of governance into the DEA forecasting methodology. Consequently, the DEA method on its own can introduce an upward bias on a regulatory forecast.

This view seems to be supported by Powerlink's data provided for this review, which shows that its own "bottom-up" replacement forecasts for the asset classes covered by the repex model are above those forecast by its repex modelling. I understand that this is not because Powerlink believes the repex model is too low, but it is expected that as further analysis is undertaken on its "bottom-up" plans and these plans progress through its governance process they will be streamlined and optimised further.

From experience, I believe this issue can be more significant in replacement capex as it is often more difficult to perform quantitative risk assessments and cost-benefit analysis, as may be used to determine the augmentation project plan. Therefore, when DEA is used to prepare the regulatory forecast for replacement it can often rely more heavily on "engineering judgement", which is more difficult to explain and justify in a proposal. Another consequence of this, is that it can be difficult to know whether the overall effect of the replacement plan produced through the DEA method is to maintain risk or change it. As

[6] Pg 34, Powerlink Final Framework and Approach paper, June 2015

[7] By governance, in this context, I mean the challenge good governance places on the parties raising the need for a project, which in turn can require risks assessments, financial and economic analysis, budgeting considerations, and project prioritisation.

[8] Setting aside unexpected major events.

such, it is more difficult to demonstrate that the forecast is necessary to meet the NER capex objectives.

Second, I believe the AER repex model (or similar) with suitable application can address some of the accuracy shortcomings of the DEA method.

The planning parameters (e.g. replacement decision criteria) in the model can be "calibrated" to reflect the previous actual outcomes. That is, they can be set to reflect the final result of the governance process. Or to put this another way, the asset lives and replacement costs can be set to reflect what the business (as a whole) has recently accepted, not what the asset management groups would prefer to see.

In the case of Powerlink's application of the AER model, it has adopted this approach with its lives, in most cases setting them to reflect its own historical outcomes. That is, they reflect the outcome of its governance processes; they are not "industry benchmarks" set by the asset management groups. I will discuss further below my views on areas where Powerlink has deviated from this approach. This is most notable with its modelling of the towers forecast.

With regard to ensuring the forecast is only sufficient to maintain the risk position, I have observed some stakeholders raising concerns that the calibration of the model to previous outcomes may inherently build into the forecast similar changes in the risk position that resulted from these outcomes. For example, if the historical outcome resulted in an improvement in reliability then the forecast would include a continuation of that improvement.

I do not believe that this is a correct interpretation of the calibration process or its effect on the model.

The calibration process, using historical replacement volumes, only derives the asset lives, for the given asset age profiles, that will produce that volume of replacements. It is the ongoing aging of the assets, allowing for these lives, that then drives out the forecast replacement needs.

This forecast could be viewed as approximating the average risk position over the calibration period, not the projection of a historical trend. This has reflected how the AER has set STPIS targets historically, which typically reflected the average reliability over the previous 5-year period – not the continuation of the trend.

It is worth noting that the calibration method presently used by the AER, which relies on a backwards projection from the age profile representing the end of the calibration period (i.e. instead of a forward projection from an age profile representing the start of the calibration period), could be more prone to inaccuracies in reflecting the historical risk position.

However, one of the "enhancements" applied by Powerlink is to perform a forward projection for calibrating the model, so I would expect Powerlink's method to more accurately produce a forecast that reflects its average risk position over the calibration period.

On this point, it is also worth noting that the AER should be able to make some assessment of what occurred over the calibration period and whether it was prudent and efficient from some form of intercompany benchmarking of the calibration lives. For example, if a NSP has increased its replacements to inefficiently reduce risks then that that should be seen through shorter lives to its benchmark peers.

With regard to replacement costs, Powerlink has not calibrated these to history. The unit costs reflect its view of its forecast unit costs. As such, these costs cannot be so readily demonstrated through the model to represent an actual outcome of a governance process. The development of these costs is outside the scope of this review. Nonetheless, what is relevant to this discussion is that these unit costs should be similar to those Powerlink would have used had it developed its replacement forecast from a DEA approach, so what can be said is that their use in the AER repex model should be no better or worse than their use in the DEA approach.

Third, forecasting through the AER repex model should reduce the effort associated with conducting the revenue reset process.

I would agree with Powerlink that forecasting using the repex model should reduce its efforts, particularly with regard to producing supporting documentation. Possibly, more importantly, from my experience of conducting regulatory reviews of forecasts prepared through DEA methods, I also believe it has the potential to significantly reduce the effort of the review, on both Powerlink, the AER and other stakeholders.

From my experience of conducting regulatory reviews, DEA method can be harder to review than more simplified methods and models. A significant issue here can be simply understanding the forecasting method that underpins the DEA approach for any asset class or even planned projects within that asset class. The important point here is that often a range of analysis approaches and models will be used for different asset classes, and sometimes, projects and programs within an asset class. As such, it can be time consuming to simply understand these various methods, particularly with regard with to the various inputs and assumptions, and how and why they influence the forecast. I understand that part of the reason for recent Rule changes requiring the NSP to submit a forecasting methodology document well in advance of the regulatory proposal is to forewarn the AER of impending methodological complexities.

The AER repex model on the other hand should be a method understood at the outset by the AER (and many of the more engaged stakeholders). Because of this, it should be far more transparent to all parties what its inputs and assumptions are, how they have been prepared, how they influence the forecast, and what they mean in a regulatory context. The aim of the NSP supporting documents is largely then to simply explain how the model has been applied in the NSP's circumstances and why.

This should result in a simpler review process, where matters can be discussed and resolved on a relatively even footing. For example, during the course of this review, even though Powerlink has made many alteration to how I have previously set up and applied models of this type, this review has been much easier to conduct than other methodological reviews I have conducted of DEA type methods. Importantly, the adoption of the AER's repex model as the forecasting approach has meant that I have been able to readily conduct my own modelling investigations on matters that caused concern. This is much more difficult for the reviewer to do under the DEA approach – with some approaches where complex proprietary models have been used it is effectively impossible. This often means that that the reviewers also have to make judgements that appear arbitrary and lack transparency.

Fourth, I see no clear reason why the adoption of this method over DEA would hinder the AER's review.

Related to my third point above, Powerlinks's adoption of the AER repex model should not hinder the AER's review. If anything, it could enhance it.

Although the AER repex model is often described as a "top down" methodology, it produces a form of "bottom-up" forecast. In this regard, the forecast is developed by aggregating individual forecasts (volumes and repex) at an asset category level. Moreover, Powerlink's application of the model is similar in structure to AER RIN reporting requirements, as so its adoption should not mean that there is materially less "information" content in reported forecasts.

Also, even though it is not based upon a DEA method, I cannot see a clear reason why this would hinder detailed technical engineering reviews that the AER may decide to conduct. It is assumed that Powerlink will still make available its asset management plans and these will have been aligned to reflect the forecasts. Furthermore, the AER should still be able to request condition and asset performance information should it have concerns.

There could be a problem should the AER require cost-benefit analysis (and associated risk assessments), which is one of the assessment techniques the AER has foreshadowed. The repex model does not facilitate this type of analysis. In effect, it is assuming the life parameters reflect the economic life of the asset. For replacement, in my experience, it cannot be assumed that a DEA approach will routinely provide cost-benefit analysis either. Therefore, this limitation in the repex model is not necessarily a mark against it over DEA.

Importantly, on this matter and linked to my first point above, the repex model facilitates the form of regulatory assessment that I would expect the AER to apply, which avoids the need for detailed cost-benefit assessments. This relates to the model facilitating intra- and inter-company benchmarking, which regulators typically apply to make judgements on the prudency and efficiency of a forecast to avoid the need to perform extensive reviews of the economic efficiency of individual plans.

In a broad sense, Powerlink's application of the model means it is clear and transparent what the replacement forecast volumes are attempting to represent: it is an intra-company benchmark (or business-as-usual forecast) that reflects the continuation of its recent historical asset management practices in the face of the ongoing aging of its network. Therefore, if it can be assumed that these practices are prudent and efficient then it follows that the forecast should represent prudent and efficient expenditure – without the need for proof from cost-benefit analysis (and associated risk assessments).

Many of the other assessment techniques that the AER has available can test this assumption. The model also provides valuable information to test this assumption, and provides the framework to produce an alternative forecast should it find it is not valid. In this regard, as the AER has applied in distribution, inter-company benchmark lives and unit costs can be developed across businesses. These can then be used to test the forecast and produce an alternative.

Inter-company benchmarking is outside the scope of this review, and therefore, I make no claim whether the assumption that recent history reflect the actions of the prudent and efficient peer business is valid in Powerlink's circumstances. The point here is simply that Powerlink's use of the model facilitates this type of assessment by the AER.

Although in the four points above I have set out why I believe the AER repex model is a suitable method for Powerlink to use to prepare its replacement forecast, that is not to say DEA is not suitable or the repex model has no shortcomings.

With regard to DEA, its application typically requires additional processes to ensure it is providing a forecast that is suitable for a regulatory proposal. This will often involve various stages of internal development, presentation and challenge to mirror the tension provided by governance. More recently it appears that many businesses have also used the AER repex model (and other assessment techniques) to provide some form of validation the forecast in the context of how the AER may assess it.

With regard to the AER repex model, it can't simply be assumed that it will produce an accurate forecast. Its need to have the network represented sufficiently and needs it parameters set appropriately.

The AER has range of assessment techniques with various advantage and disadvantages, and aimed at different matters. The repex model is just one of these assessment techniques. Therefore, the AER's application of the repex model can make simplifications to normalise the assessment across businesses and ensure the AER can perform the assessment readily within the timing and resource constraints of it review. It can then test the findings from its modelling with findings from other techniques in order to set the repex forecast.

If a NSP is relying on the repex model as the basis of its forecast then I believe it is more important for it to bring in its knowledge and understanding of its network and drivers of replacement to "enhance" the forecasting ability of the model. It is less likely it can simply apply the AER's assessment process and assume it will produce a forecast appropriate for its regulatory proposal. In this regard, a large part of this review has been investigating the "enhancements" applied by Powerlink.

Furthermore, in the same way that the suitability of a DEA forecast can be supported by repex modelling. I do not believe that the repex model should be applied by an NSP in isolation from its asset management knowledge. The overall forecasting method should incorporate processes to compare and reconcile the repex model forecast with actual asset management information, and confirm that actual asset knowledge and plans support the forecast. This should be an important part of the validation process of the repex model's forecast. This is particular so for transmission businesses where I would expect them to have good knowledge of asset condition and performance for most assets.

I have requested comment from Powerlink on how it has used this knowledge to validate the forecasts produce by the repex model. Powerlink has advised[9]:

"Powerlink uses its Asset Management Plan (AMP) in two complementary manners to inform and validate the forecasts produced by the Repex Model:

1. *The process of area planning of the high voltage network identifies whether there is an enduring need for each network element that is approaching its end-of-life decision point within the outlook period. The assessment of enduring need considers whether the assets approaching their end-of-life could be retired from service without replacement and the remaining network still have sufficient capacity for Powerlink to meet its reliability of supply obligations into the future. Where the AMP has identified assets that can be retired from service at their end-of-life without replacement these assets are removed from the Repex Model age profile. This ensures that no forecast capex can be generated by the Repex Model in relation to these assets.*
2. *The AMP provides for an annual update of a risk-based assessment of asset reinvestment needs. The replacement quantities from this risk-based assessment can be compared with the forecast quantities produced by the Repex Model… "*

Reviewing Powerlink's asset management plans is outside the scope of this review. However, Powerlink's response on this matter provides some comfort that this matter has been considered important by Powerlink and it has some process in hand.

3.3.2 Set-up of repex model

As noted above, the set-up of the forecasting model covers how Powerlink has represented its network in the model. This is an important factor in the accuracy of the forecast produced by the model. The key matters are:

- the asset categories that Powerlink is using to represent its network
- the age profiles for each asset class
- the asset life model.

Broadly, from this review I am satisfied that the Powerlink model has been set up appropriately. There are a few matters that I have some concerns, which I will cover below. But, to a large extent, the set-up of the model is how I may have expected for a TNSP, in the context of being the basis for the replacement forecast in a regulatory proposal. In this regard, the set-up is closely aligned to the relevant templates in AER RINs, with some alterations to either account for data discrepancies or improve the forecasting accuracy.

asset categorisation

The selection of the appropriate set of asset categories in a model can be specific to the NSP's circumstances and the purpose of the model. It is beyond the scope of this review to

[9] Provided in response to Question 1 of Information Request #1

perform detailed investigations of this matters. Nonetheless, I am reasonably confident that the categories selected by Powerlink should be sufficient for the purposes of the model for the following reasons:

- From my experience of preparing and reviewing models of this type, the categories chosen by Powerlink for the relevant asset classes in the model align with what I would typically expect – other than the possible issues I raise below.
- I have reviewed Powerlink's rationale for categorisation in each asset class and this appears reasonable.
- The categories selected by Powerlink are broadly in accordance with the categories defined by the AER in its age profile and replacement, which I understand the AER has defined partly to capture life and cost differences between asset types. Powerlink has added a number of categories, but these additions seem reasonable in Powerlink's circumstances and should enhance the forecasting accuracy of the model. These additions are as follows:
  - In addition to the AER classifications, towers are differentiated by their corrosion zone, which affects their life, and the ability to "refit" (i.e. extend the life) of towers, which affects its life and unit costs
  - The AER has not defined the asset categories for the secondary systems and buildings asset class. This is at the discretion of the TNSP. Powerlink has defined a number of categories in these two asset classes to capture the key asset types.

I do however have some concerns with asset categorisation used for the switchgear and secondary systems asset classes. I will discuss the specific asset categories in each asset class and these concerns further in the asset class sections below.

Asset category age profiles

The age profiles for each asset category are critical inputs to the repex model. The forecast produced by the model for any specific asset category will typically be sensitive to the age profile, and therefore, it is important that it is reasonably accurate.

It is not within the scope of this review to audit Powerlink ages profiles. Nonetheless, I am reasonably confident that, to a large extent, the process Powerlink has applied to generate age profiles should be appropriate. This view is based on the following:

- A topic of discussion at the workshops was Powerlink's preparation of age profiles. As noted above, these profiles have been generated from asset data contained in Powerlink's asset data systems. As I understand it, these systems should hold reasonably accurate data on the quantum and date of installation of all the assets defined in the model. From a process point of view, there was nothing raised by Powerlink that gave me concern that the age profiles would not be suitable for the repex model.
- The method used to generate the age profiles for the forecasting model is equivalent to methods applied by Powerlink to generate the age profiles it has reported in recent

category analysis RINs. As far as I am aware, this process has been audited for Powerlink and accepted by the AER as part of the RIN approval process.

- Powerlink did discuss during the workshops that it has made some changes to the RIN age profiles to account for data discrepancies it has discovered through the modelling process and adapt them for modelling purposes. This mainly concerns alterations to the switchgear category. Also, as noted above, Powerlink has excluded some assets to ensure there is not double counting between the repex model forecast and its bottom-up forecasts. It has also excluded assets it does not intend to replace (when they reach the end of their life) to ensure these are not incorrectly forecast for replacement. The reasoning for these changes appears appropriate to me.

Although, I have found no reason to consider that Powerlink's process for preparing age profile is not appropriate. I have some concerns with its implementation. During the course of this review, I have raised queries with the modelling of some asset classes. This has resulted in Powerlink advising that there could be errors in the age profiles of a number of the asset categories, covering:

- current transformers in the switchgear asset class
- the substation and telecommunications secondary system categories
- buildings asset categories.

I understand that at this stage, these age profiles - as with the models - are still in draft form. Nonetheless, it will be critical that the final age profiles are accurate. Therefore, it may be important that all age profiles are thoroughly reviewed – and possibly audited - before the models and forecast are finalised.

the asset life model

The asset life model concerns how the repex model decides when and how many assets within the age profile will need to be replaced in each year over the forecast period. As noted above, Powerlink has assumed a life that is normally distributed, and assumed that the standard deviation of this distribution is the square root of the mean life.

This form of life model is in accordance with how the AER applied the model in the recent NSW, Queensland and South Australian DNSP determinations. It is also in accordance with how I have set up models for previous modelling exercises I performed, when acting as a technical advisor to the AER.

There certainly could be some argument that alternative distributions could be more appropriate. For example, a Weibull distribution is often used when modelling end-of-life effects; or an alternative standard deviation could be assumed. However, typically these require more effort to determine, as they can require more model parameters to be determined and will require more analysis and documentation to justify why an alternative to the AER assumption have been applied. In my experience, provided the asset categories are defined appropriately and the calibration is performed correctly then the improvement through an alternative distribution is typically small.

Therefore, I believe that the life model assumed by Powerlink should be appropriate for these purposes.

That said, I will address this matter further when I discuss the possible reasons for significant differences between the calibration model's forecast and the forecast model. These differences could be due to the assumed life model not reflecting the actual replacement dynamics in limited circumstances. The important point here is that my investigations on this matter suggest that these difference are more likely due to the effects of the asset categorisation and set up of the life parameters, not the assumed life model.

3.3.3 Setting of the model planning parameters

The unit cost and asset life parameters for each asset category are critical model inputs. In this section, I will discuss my views of the approach Powerlink has used to determine these two sets of parameters.

3.3.3.1 Asset unit costs parameters

As indicated above, the set of unit costs used in the repex model are not prepared through model or by direct calibration to historical cost. This differs to the approach the AER typically uses and I have used in previous modelling exercises, where a set of unit costs will be calibrated to reflect historical costs. The AER has also developed model scenarios that use the NSP's forecast unit costs, but it will typically use this scenario to gauge whether or not the forecast unit costs are above the historical unit costs.

As also noted above, the method Powerlink has used to develop its set of forecast unit costs is not within the scope of this review. Furthermore, I am unable to assess whether the forecast unit costs are above or below historical unit costs. The problem here is that the forecast unit costs include overheads, but the historical cost reported in the relevant RIN templates do not. Powerlink has advised that there is not simple cost allocation proportion to add or remove overheads from individual unit costs.

Therefore, I cannot provide any views on the appropriateness of the forecast unit cost. This is not to say that historical unit cost should be used and Powerlink is in error for using the forecast unit costs. Rather, since forecast unit costs do not represent the intra-company benchmark (as its lives do), Powerlink may require more substantial supporting information should these cost be higher than history. To address this matter, Powerlink will need to consider whether it can put these unit costs on the same basis as the historical costs in order to reconcile the forecast unit costs to history. Ideally, this should show whether forecast costs have increased or reduced, in aggregate and at the asset class and asset category level.

3.3.3.2 Asset lives parameters

A noted above, Powerlink has set its asset lives to reflect its historical outcomes (i.e. an intra-company benchmark reflecting the continuation of historical practices). It has used a "hybrid" approach to determine this set of asset lives. To a large extent, these lives are "calibrated" using the repex model. However, in some circumstances, it has applied some adjustments.

Broadly, I consider the process used by Powerlink to derive these lives is appropriate for the purposes of the forecast. I note it differs (in process – not intent) from the approach that the AER has applied recently. However, I have found the alterations to be aimed at improving the accuracy of the calibration and forecasting process. Nonetheless, I have a number of concerns with the implementation. Some these concerns are quite specific to circumstances in individual asset groups. Therefore, I will discuss them in more detail in the asset group sections that follow.

The following discusses my considerations that have led to this view.

the role and use of a calibration model

As noted above, Powerlink has used a second repex model to calibrate the asset lives to historical outcomes. This model uses a 2009 age profile and uses a forward projection through the calibration period to ensure the model forecast matches actual historical outcomes.

As noted above, this approach differs from the calibration method the AER and I have applied when using the repex model to assess repex forecasts. In these previous situations, the forecast model has been used and a backward projection has been applied.

Provided the calibration model has been set-up correctly (which I will cover below), the approach adopted by Powerlink should provide a more accurate calibration. In fact, where circumstances permit, I believe it should be the preferred approach. The important point here is that the method both the AER and I have used previously has been adopted because of limitations in the available data. In this regard, suitable age profiles (or at least confidence in their suitability) have not been available to perform the forward projection.

the set-up of the calibration model

The set-up of the calibration model concerns similar matters to the forecast model, namely, asset categorisation, age profiles and the life model. Similar to my findings on this matters for the forecast model, I have found that to a large extent the calibration model is set up appropriately. However, I have some concerns which are linked to my concerns with the set-up of the forecast model raised above.

- **Asset categorisation** – Ideally, the asset categories in the calibration model should match the asset categories in the forecast model. Powerlink has reduced the categories, in the towers and switchgear asset groups. These changes have been made for various reasons:
  - To increase population sizes in the age profiles and calibration volumes. Powerlink's view is that this alteration will increase the accuracy of the calibration process (i.e. if populations are too small then the calibration of the life may not be an accurate estimate of the life). This has been applied in circumstances where Powerlink considers asset categories will have similar drivers and so similar lives (e.g. across voltage levels within an asset group).

  - In some limited circumstances where data is not available to prepare the relevant 2009 age profiles; for example, tower foundation data necessary to prepare the tower age profiles.

  I am not aware of strict rules that can be applied to define suitable population sizes. As such, I cannot provide definitive comment on whether these adjustments were necessary or appropriate. Nonetheless, the adjustments have amalgamated asset categories that I would expect to have similar lives. As such, given the probabilistic life model, I would not expect this to have a significant effect on the overall forecast at the asset class level (i.e. this simplification may understate the forecast in some categories, but this should be balanced by other categories where it is overstated).

  Related to the point above on concerns I have with the categories used in the forecast model for the secondary systems asset class, should it be deemed appropriate to have additional categories to capture different technology then this would need to be mirrored in the calibration model.

- **Asset age profiles** – To perform the forward calibration, it is important that the age profile that reflects the start of the calibration period (2009 in the case of Powerlink) has been prepared on a consistent basis to the forecast model's age profile (2014 in the case of Powerlink). An artificial difference in the two age profiles would result in a life being determined through the calibration model that was not appropriate for the forecast model, which could cause artificial increases or reductions in the forecast replacement volumes.

  Ideally, this requires the same data systems, and consistent processes and assumptions when developing the age profiles. Based upon the explanations provided by Powerlink, this appears to be the case where the 2009 age profile has been generated by starting with the same data and systems used to prepare the 2014 profile, but "rolling-back" the changes that have been entered into the data system since 2009[10].

  In addition to this qualitative reasoning, I have also undertaken some high-level analysis of the age profiles at an aggregate asset class level[11]. Other than my concern with the errors in the age profiles noted above (which affects the calibration model also), the age profiles appear to be reasonably consistent.

  All that said, given my concerns on errors in implementing the process to prepare age profiles, Powerlink should consider reviewing the calibration model's age profiles to ensure all changes to the forecast models age profiles can be explained.

- **The life model** – Obviously, it is important that the life models are consistent between the calibration model and the forecast model. That is, Powerlink's calibration model must assume a normally distributed life, and assume that the standard deviation is

[10] It is worth noting that had Powerlink advised that it had used a profile that it had prepared in 2009, but it had no evidence that it was prepared on a consistent basis then I would be far more reluctant to accept it as appropriate.

[11] This analysis has involved a high level comparison of the two age profiles to determine whether quantum changes and the overall shape of the profiles are reasonably consistent given the replacements that have occurred.

the square root of the mean life. Based upon the calibration models provided for review, this is the case.

the historical replacement volumes – calibration outcomes

The use of the appropriate historical replacement volumes are clearly an important input to the life calibration process. As far as I am aware, the AER routinely uses the replacement volumes reported in Table 2.2 of the category analysis RIN directly as the input to its historical calibration. This differs slightly from Powerlink's application. As noted above, Powerlink has used these volumes as its basis, but has adjusted these in circumstances where it believes the adjustments will result in a more accurate calibration.

It is not within the scope of this review to conduct an audit of the specific adjustments to confirm they have been calculated correctly. Nonetheless, from the information provided by Powerlink for this review, the basis for each adjustment appears valid. Obviously, in circumstances where there is an error in the reported volumes then this should be corrected for calibration. Furthermore, it is appropriate for Powerlink to remove non-age/condition replacements if this volume is material.

Further comments on the adjustments to specific asset classes are provided in the asset class section below.

the calibration process

The calibration process involves setting the lives in the calibration model to ensure that its forecast, over a defined period, matches a predefined outcome (i.e. historical replacement volumes in Powerlink's case).

From a formulaic point of view, the approach used by Powerlink to perform this process within the calibration model seems correct, and is similar to the method I have used and I understand the AER uses. More specifically, for each asset category being calibrated, Powerlink uses excel's "goalseek" function to find the mean life for that asset that results in a zero error between the model's forecast and the required outcome.

However, the definition of the error is different to how the AER would typically calibrate lives, and I have calibrated lives when assessing repex forecast. In this regard, the Powerlink calibration model compared the average annual forecast from the model, over a 5-year period 2009/10 to 2013/14, against the average annual outcome over a 6-year period, 2008/09 to 2013/14.

The AER's assessment process has used a 5-year period for the outcome. There may be varied reasons for the AER preferring a 5-year period, but I have used this period previously because it reflected the duration of a regulatory period and should capture a reasonable level of replacement to aid the calibration process. My concern was that a shorter period could be biased due to the effects of uneven regulatory incentives across a regulatory period or reduced accuracy due to the "lumpiness" of some replacement activities; and a longer period may miss productivity improvements that may have occurred recently.

It is important that I stress that these were assessment considerations. There is no reason why a NSP could not deviate from this if it believed it would produce a more accurate forecast. I understand from discussion with Powerlink on this matter that 6 years was chosen as it reflected the volumes reported to the AER since its new RIN reporting obligations and Powerlink preferred to use a longer period to ensure it had a longer period of replacement volumes, which it considered should lead to a more accurate estimate of the life.

I agree with Powerlink that this should produce a more accurate estimate of the life, provided the two factors I noted above are minimal (i.e. the effects of uneven incentives on replacement levels and productivity changes). It *does* however also result in a small inconsistency for the forward projection method, as it is picking up one year that ideally should be treated as a backward projection.

It is difficult in this review to formally investigate whether this concern is material. From my high-level analysis of replacement volumes[12], it appears that the forecast for switchgear and secondary equipment could increase from a move to a 5-year outcome period, but the towers forecast could reduce.

Given this is only a 1-year difference to a 5-year calibration period and there does not appear to be an intentional bias in this assumption, I am not raising this a major concern that should be corrected. However, Powerlink could consider investigating the effects of moving to a 5-year outcome period for calibration. If it results in a significantly different forecast, it may need to ensure that the reasoning for adopting the 6-year year outcome period is clearly explained and justified.

Potential calibration issue due to expensed replacements

One potential issue with the replacement volumes used to calibrate the model concerns how Powerlink defines an asset in its systems and so decides whether to capitalise or expense its replacement.

I understand that assets are typically defined at a fairly high level in Powerlink's system e.g. a line build section is an asset, not the tower or conductor; similarly a substation bay is an asset, not a circuit breaker or switch within the bay. This has not affected the set-up of the model as Powerlink treats these as assets within the model. However, this can affect replacement volumes used to calibrate model lives, as any replacements that were expensed are not counted[13].

If these expensed volumes were relatively high then the true life of the asset would be shorter than suggested by the model. The important point here is that this may place the asset category further through its replacement cycle, which means the model could be overstating the capitalised replacement forecast – assuming a similar proportion of replacements would be expensed in the future[14].

[12] This analysis is simply comparing the average 5-year volume to the average 6-year volume. I have not attempted to recalibrate the Powerlink models.

[13] I understand that this does not affect "Telecommunications" assets as these are defined as assets within Powerlink's systems at a fairly low level e.g. MUX, fibre-optic drivers.

[14] The important point here is that the repex model, using the shorter life, would produce a higher forecast replacement volume. But the proportion that would be capitalised would be lower, assuming a similar proportion of replacements would be expensed in the future.

To assess whether this could be significant I have requested comment and data from Powerlink on expensed replacement volumes[15]. Powerlink has advised:

"*Powerlink has reviewed all Operational Refurbishment (OR) projects that have been approved since 1 July 2008 to develop an estimate of selected equipment replacements due to age / condition that have been expensed. OR projects represent planned replacement of equipment items only. Equipment that is replaced immediately following in-service failure will not be captured by this estimate but should be substantially fewer in number.*"

This response was supported with the volumes of expensed age/condition driven replacements for the switchgear category.

I have undertaken some indicative investigations through the repex model of the effects of including these additional volumes in the calibration and forecasting process. For this analysis I assumed that the relative proportion of expensed versus capitalised replacements would remain the same.

My investigations found that the effects of the expensed volumes was small (<$1 million per annum). Therefore, this may not be a significant issues i.e. the effort of modelling may not outweigh the improved accuracy. However, data was only provided on switchgear. It is not clear if similar expensed replacements could affect other categories, particularly towers. Therefore, Powerlink may want to consider this matter further.

3.3.4 Quantitative assessment of calibration process

In the section above I have set out my, largely, qualitative considerations of the appropriateness of the method Powerlink has applied to set up the repex model and calibrate the asset lives. To investigate further whether they may be some underlying issue with how this method has been applied, I have also examined the profile of volumes being forecast from the calibration model compared to the forecast model. Because of the approach that Powerlink has taken using a calibration and forecast model, these profiles should be reasonably consistent. Therefore, significant variations could suggest a problem with the model set up, calibration or input data.

Table 2 summarises the results of this analysis, indicating the average per annum volume of replacements forecast by the two models in different time periods relevant to the calibration period and forecast period.

[15] Question 2 of Information Request #1

Table 2 Summary of model volume profiles

	Average volumes per annum				
	calibration model			forecast model	
sub-group	2010-14	2015	2018-22	2015	2018-22
Towers Replaced	*114*	*69*	*35*	*7*	*8*
Towers Refit				*108*	*218*
towers - all	**114**	**69**	**35**	**114**	**226**
Switchgear – CB	*26*	*20*	*18*	*21*	*15*
Switchgear – switches	*109*	*101*	*86*	*106*	*83*
Switchgear – VT	*49*	*39*	*34*	*48*	*31*
Switchgear – CT	*54*	*57*	*60*	*29*	*30*
Switchgear - all	**238**	**217**	**198**	**204**	**159**
Substation	*62*	*31*	*29*	*64*	*28*
Telecommunications	*69*	*53*	*97*	*124*	*106*
Metering	*10*	*12*	*16*	*3*	*6*
Secondary - all	**141**	**96**	**142**	**192**	**140**
Buildings	*12*	*6*	*4*	*27*	*7*
Site Infrastructure	*2*	*2*	*3*	*3*	*3*
Buildings - all	**14**	**9**	**7**	**30**	**10**

The key findings from this analysis are as follows:

- Towers – The is a significant inconsistency between the two models.

  The calibration model suggest a significant future decline in replacement/refit volumes, whereas the forecast model suggests a significant increase.

  Care is need however in drawing conclusions from these differences as the calibration model only represents a component of towers, and therefore, the calibration model cannot be fully reconciled to the forecast model. This matter will be discuss further in the section below, which discusses the modelling of towers in more detail.

- Switchgear – Other than current transformer (CT) categories, the two models compare fairly well.

  As noted above, there is an error in the age profiles for the CTs asset categories, and this is affecting these results. This matter will be discuss further in the section below, which discusses the modelling of switchgear in more detail.

- Secondary systems - There is a noticeable inconsistency between the two models.

  With regard to the substation and telecommunications asset categories, the forecast over 2018 to 2022 is fairly consistent between the two Powerlink models. However, the forecast model is predicting a significantly higher number of replacements in 2015 than the calibration model. This suggests that the forecast model is predicting the need to replace assets that the calibration model has already replaced.

This result suggests there could be some problem with how the Powerlink models have been set up and calibrated. This could potentially alter the forecast, if the base year of the forecast model is changed i.e. it is moved from 2014 to 2015.

With regard to the inconsistency in the metering category, as will be discuss below, this category is not directly calibrated through the calibration model. Therefore, the apparent inconsistency is not relevant.

These matters will be discuss further in the section below, which discusses the modelling of secondary systems in more detail.

- Buildings and infrastructure – There is a noticeable inconsistency between the two models.

  Most notably for the buildings asset categories, the forecast in 2015 is much higher than predicted by the calibration model. This suggests there could be some underlying problem with the Powerlink models.

  This matter will be discuss further in the section below, which discusses the modelling of the buildings and infrastructure asset class in more detail.

3.4 Asset group modelling considerations

3.4.1 Towers

3.4.1.1 Appreciation of approach

Asset categorisation

The forecast model uses 22 asset categories to represent the towers asset class. The following four classifications have been used to allocate towers to these categories (i.e. a model asset category is defined as a combination of these four classifications):

- Tower foundation type – Towers are differentiated into “grillage” and “non-grillage” foundation types. Powerlink uses this classification as it can usual perform a lower cost refit (i.e. life extension) of towers of a non-grillage design as they near their end-of-life, whereas it usually has to replace towers of a grillage foundation type. As such, Powerlink uses this classification to distinguish between both unit cost and life parameters in the model.
- Corrosion zone – Towers are classified by the corrosion zone they are located (specified as either a B, C or DEF zone). Powerlink considers that the corrosion zone defines how quickly the towers age, and so affects the life parameter of the tower.
- Design voltage – Towers are also classified by the design voltage (specified as 5 voltage ranges: <=33 kV; >33 kV <=66 kV; >66kV<=132kV; >132kV<=275kV; >275kV<=330kV). Powerlink considers that the design voltage affects the unit cost parameter, but not the life.

- Circuits number – Finally, towers are also classified by the number of circuits they carry (specified as either “single” or “multiple”). As with the design voltage, Powerlink considers that the number of circuits affects the unit cost parameter, but not the life.

Life calibration method

Powerlink has used a ”hybrid” approach to prepare the various asset lives for the forecast model’s asset categories:

- the calibration model is used to estimate a single mean replacement life for all towers in the DEF classification corrosion zone.
- various “offsets” to this life are defined by Powerlink to reflect the replacement lives for the other corrosion zones, and the refit life for all corrosion zones.

The calibration model uses a single towers category representing all towers in corrosion zone DEF. The volumes used to calibrate this life are different to those reported in RINs. Powerlink has provided a workbook showing the reconciliation between the reported RIN volumes and the volumes used for calibration. The table below summarises this reconciliation[16].

Table 3 Tower calibration volumes

	Reported in RIN (2008/09 to 2013/14)	**796**
added	volume omitted in error from the RIN reporting	4
exclude	volumes Powerlink does not consider where driven by age and condition	72
exclude	volumes associated with corrosion zones B (0) and C (23)	23
	Calibration volumes (for corrosion zone D)	**705**

The “offsets” to this calibrated life have been calculated by Powerlink as follows:

- The replacement life for corrosion zone B and C are defined as:
  - corrosion zone *x* replacement life = corrosion zone *D* replacement life + corrosion zone *x* life offset

  The two life offsets have been estimated by Powerlink from analysis of its towers populations[17]. In this regard, each line “built section” has been given a life expectancy by Powerlink asset management group based on reviews of asset management information for that built section, such as defect reports and condition assessments. The number of towers in each built section and the corrosion zone for that built section is known, and therefore, the average life for all towers in each of the corrosion zone classifications is calculated to provide the two offsets.
- The refit life for corrosion zones B, C and DEF are defined as:

[16] These volumes are slightly different to those in the draft calibration model provided for this review, which I understand is because this model reflects an earlier view of the adjustments.

[17] Analysis provided in Excel workbook, “Built Section Life Expectancy Offsets”

- corrosion zone *x* refit life = corrosion zone *x* replacement life - refit offset

A refit offset of 5 years (applicable to all corrosion zones) has been assumed by Powerlink based upon recent experience.

The table below summarises the towers lives derived by Powerlink based upon this hybrid approach (the brackets signify the offsets).

Table 4 Tower lives

Corrosion zone	Replacement life	Refit life
B	64.3 (18.5)	59.3 (-5)
C	58.7 (12.9)	53.7 (-5)
DEF	45.8 (calibration model)	40.8 (-5)

3.4.1.2 Review discussion

As discussed above, I consider that the approach Powerlink has taken to model the towers asset class is reasonable. In this regard, from a methodological point of view, the rationale for the asset categories Powerlink is using in both models and the hybrid approach Powerlink has taken to develop lives both look reasonable for its circumstances.

However, in Section 2.2 I noted that the towers asset class was the most significant asset class and Powerlink is forecasting a large increase in replacement/refit volumes in this category. Furthermore, in Section 3.3.4 I noted the inconsistency between the forecasts produced by the calibration model and forecast model. These two matters are related to the same issue, which I will discuss below.

From my review of data provided by Powerlink during this review the following is occurring through the models.

- The main activity on Powerlink's towers over the calibration period has been the replacement of grillage towers in the DEF corrosion zone. There have been very few refits in any corrosion zone and very few replacements in the C and B corrosion zone.
- The forecast model is very much driven by the forecast refit of non-grillage towers, as there are very few grillage towers remaining. The refit of DEF towers is increasing modestly. However, the main increase is due to the forecast refit of towers in the B and C corrosions zones, which are forecast to increase significantly from historical levels.
- The calibration model does not model towers in the C and B corrosion zones, so these towers cannot be reconciled to the forecast. It also does not differentiate between grillage and non-grillage towers, so the profile of refits cannot be reconciled to the forecast.

My concern with these results is that the large increases seen in the C and B corrosion zone towers cannot be linked directly to the historically very low replacement/refit volumes of these towers. As such, the modelling approach does not implicitly indicate whether the offsets assumptions are appropriate.

To investigate the possible significance of this issue, I have used data provided by Powerlink to develop an "indicative" calibration model that I have used to examine the possible lives for non-grillage towers in C and B corrosions zones and the resulting forecast.

To prepare this model I have:

- used the age profiles for the C, B and DEF non-grillage towers provided in the forecast model – there have been very few refits of these towers over the calibration period, so this should be a good approximation of the profile in 2009
- used historical refit volumes for the C, B and DEF provided by Powerlink to calibrate the non-grillage lives[18].

This analysis suggests the refit lives for the C and B corrosion zone could be significantly longer than Powerlink is assuming through its offsets (see **Error! Reference source not found.**).

Table 5 comparison of tower refit lives

	refit lives	
corrosion zone	Powerlink	Nuttall Consulting
B	59.3	76.6
C	53.7	62.2
DEF	40.8	40.8

If these lives are used in the forecast model then the forecast refit volumes for the C and B towers is significant lower, resulting in a 66% reduction in forecast tower refits over the next regulatory period (see **Error! Reference source not found.**). This variation to the model also shows a much better consistency between the calibration and forecast models' forecasts.

Table 6 comparison of tower refit forecast (2018 to 2020)

	average refit volumes per annum	
corrosion zone	Powerlink	Nuttall Consulting
B	40	1
C	136	31
DEF	43	43
total	**218**	**75**

During discussion on this matter with Powerlink, it commented that it has concerns that the low volume of historical replacements on C and B towers may affect the accuracy of this type of calibration. I accept that low volumes of replacement can reduce the accuracy of estimating what the mean life *is*. However, provided the model is set-up correctly, the fact that a large population of tower must have "survived" does suggest what the life could *not* be. The important point here is that in a model of this type it is partly the volumes of towers that have survived that drives the life estimate, as well as the towers that have been

[18] Provided in the file Replacement Quantity Breakdown – towers 20150921_Nuttall, provided in email, dated 21/9/15

replaced. Assuming the model is set up correctly, this analysis tells me that it is very unlikely that the refit lives for C and B towers could be as low as Powerlink's offsets suggest – or Powerlink would have needed to refits more C and B towers over the calibration period.

Powerlink has advised during discussion that the pattern of refits in its forecast aligns with expectations from its engineering analysis. I am unable to say definitively whether the offset or the model set-up are incorrect, or a combination of both. Therefore, I raise this matter as a significant concern with the modelling.

Powerlink should consider investigating this matter further. This may require the engineering analysis to be examined to better understand what is driving the need to refit C and B towers, and whether this indicates how the model could be altered to better reflect this.

If the model cannot be altered then it will be important that offsets associated with the C and B towers are supported with fairly robust analysis and documentation.

3.4.2 Switchgear

3.4.2.1 Appreciation of approach

Asset categorisation

The forecast model uses 20 asset categories to represent the switchgear asset class. The following two classifications have been used to allocate assets in this asset class to these categories:

- Asset type – switchgear is classified by asset type, specified as follows:
  - Air insulated circuit breakers[19] (counted as 3-phase units)
  - Air insulted isolators and earth switches (counted as 3-phase units)
  - Voltage transformers (VTs) (counted as single phase unit)
  - Current transformers (CTs) (counted as single phase unit)

  Powerlink uses this classification to distinguish between both unit cost and life parameters in the model.
- Design voltage – Switchgear is also classified by the design voltage (specified as 5 voltage ranges: <=33 kV; >33 kV<=66 kV; >66kV<=132kV; >132kV<=275kV; >275kV<=330kV). Powerlink considers that the design voltage affects the unit cost parameter, but not the life.

The following two points are important in appreciating the modelling of the CT asset categories:

- RIN Switchbay age profile enhancement - Powerlink has advised that there is a significant difference for the age profiles used in the model from those reported in

[19] Gas insulated circuit breaker categories are also defined in the model, but these are not used as Powerlink only has young breakers of this type and is not anticipating any replacements.

the RIN. In the RIN data, Powerlink reported on the total count of switchbays, not the quantity of equipment within the switchbay. Each switchbay was given a single category, being either circuit breaker, switch, VT or CT, based on the hierarchy indicated by the RIN. For example, circuit breaker were at the top of the hierarchy, based on the reporting in the RIN. Therefore, if a bay had a breaker, then that bay was considered a breaker bay (only). The switches, VTs and CTs were then not further reported for that bay. If there was no breaker, but a switch then it was considered a switch bay, and so forth.

Additionally, some equipment not associated with a switchbay (e.g. isolator / earth switch or VT on a bus), were not captured in the RIN data, as the bus is not considered a switchbay asset.

In the repex model, Powerlink is modelling the replacement of equipment within the bays. Given, for example, a single (RIN) “circuit breaker-bay”, will typically have multiple CTs, VTs, and switches within it. New age profiles have been generated by Powerlink specifically for the repex modelling to provide accurate equipment-level age profiles, for switches, VTs and CTs.

- Adjustments for dead-tank circuit breakers – Powerlink has a population of dead-tank circuit breakers. Dead-tank circuit breaker incorporate the CTs inherently in their design, and so, CTs associated with these breakers are not counted. Therefore, Powerlink has added the CTs associate with these breakers into the age profiles.

Life calibration method

Powerlink has used the calibration model to calculate the lives for the four asset types noted above.

The calibration model uses four asset categories for calibrating the lives of the four asset types (i.e. circuit breakers, switches, VTs and CTs). These asset categories aggregate all assets across the voltages in each asset type.

The volumes used to calibrate this life are different to those reported in RINs. Powerlink has advised that the adjustments are to allow for two factors:

- The removal of replacements that did not occur for age/condition reasons. Powerlink has advised that this is mainly due to replacement that occurred over the calibration period to replace some switchgear because fault levels exceeded the fault level rating of the switchgear, which was driven by new generation connections raising fault levels on the network. There were also some cases where another asset was replaced (e.g. a power transformer) and this required the replacement of the switchgear.
- In many cases where a breaker and its CTs are at the end of their life, Powerlink now uses a dead-tank circuit breaker. These CT replacement volumes are not recorded in RIN reporting because the CT is inherent in dead tank breaker design. Therefore, the CTs volumes used for calibration have the additional aged CTs that were replaced via the use of a dead-tank breaker added back in.

3.4.2.2 Review discussion - switchgear

In Section 3.3.4 I showed that the circuit breaker, switch and VT asset categories showed fairly good consistency between the calibration and forecast models, which supports a view that the modelling is valid. However, I noted an inconsistency between the forecasts produced by the calibration model and forecast model for the CT asset categories, which suggest there could be a modelling issue with these asset categories.

I will discuss my further investigations of this matter here.

The inconsistency related to a very large reduction in forecast replacement volumes in Powerlink's forecast model compared to its calibration model. In this regard the forecast volumes over the next regulatory period predicted by the forecast model are half those predicted by the calibration model.

During the course of this review, I raised this concern with Powerlink and noted that there was a large difference between the 2009 age profile in the calibration model compared to the 2014 age profile in the forecast model (the 2014 age profile has 490 (20%) less CTs than the 2009 age profile). Powerlink has advised that there is an error in its CT age profiles, associated with the adjustments made to allow for dead-tank breakers[20]. Powerlink has advised that these were counted twice for the 2009 age profile, but not at all for the 2014 profile, and provided revised age profiles.

I have recalibrated the life of the CT asset categories using the revised 2009 age profiles and used these revised lives to recalculate the forecast in the forecast model using the revised 2014 age profiles. This modelling indicates that the forecast over the next regulatory period would increase by approximately 25%, resulting in an increases of approximately 11 CT replacements on average per annum. This reduces the inconsistency, but the models still show an approximate 20% reduction in the forecast compared to the calibration model.

I have investigated this matter further and still have concerns that there may be errors in the age profile. I also have concerns that Powerlink may be treating the CTs associated with the existing dead-tank CB in the forecast model incorrectly.

With regard to the age profiles:

- the 2014 age profile still have noticeably fewer CTs compared to the 2009 age profile (~200 less)
- there are approximately 800 less CTs in the 2014 age profile that were installed at or before 2009 compared to the 2009 age profile; this number is a lot more than the replacement volumes
- the adjustments associated with dead-tank breakers suggest that there was no change the number of dead-tank breakers between 2009 and 2014, which suggest they may have a significantly different life from the CTs.

These matters have been raised with Powerlink, but I understand it is still in the process of investigating them.

[20] Advised in email, dated 2/10/15

With regard to my concern with the treatment of the CTs associated with dead-tank breakers, Powerlink has advised that it has added CTs associated with dead-tank breakers to the CT age profile so it can decouple for forecasting purposes CT replacements from breaker replacements. My understanding however is that dead-tank breakers will be replaced because of the condition of the breaker, not the CT. Therefore, the CT life may not be appropriate and the breaker life should be used. However, the model has a shorter life for breakers than CTs. This conflicts with my point above concerning the dead-tank breaker age profile, which suggests dead-tank breakers may have a longer life than CTs. This matter is further complicated by the fact that dead-tank breakers may not necessarily be replaced by live-tank, and vice versa, which will affect the appropriate unit cost.

This suggests that ideally CTs associated with dead-tank breakers should not be added to the CT age profile, and dead-tank and live-tank circuit breakers may need to be modelled separately (if they have a significantly different live). Furthermore, the unit cost for dead-tank and live-tank breakers and CTs will need to be set correctly to represent Powerlink's best estimate of the relative proportions of dead-tank and live-tank breakers replacements, and the proportion of CT replacements that occur through the use of dead-tank breakers.

Given the possible error in the age profile it is difficult to say whether this additional modelling effort is worth the improved accuracy. Therefore, Powerlink will need to consider all these matters together.

3.4.3 Secondary and telecommunications

3.4.3.1 Appreciation of approach

Asset categorisation

The forecast model uses three asset categories to represent the secondary and telecommunications asset class:

- substation bay and non-bay systems, covering protection/control schemes and associated panels and wiring
- telecommunication systems
- metering systems, associated with revenue metering of generators, NSPs and customers.

These three categories differentiate between both life and unit cost parameters for these asset types.

It is worth noting that secondary systems associated with SVCs are not included as Powerlink is not anticipating the need for capex to replace these systems.

Life calibration method

Powerlink has used the calibration model to calculate the lives for secondary systems and telecommunications system asset categories separately. The calibration model uses two equivalent asset categories for this purpose.

The volumes used to calibrate these two lives are different to those reported in RINs. Powerlink has advised that the adjustments are to correct a discrepancy in how replacement volumes were calculated for the RIN. For RIN reporting, volumes were calculated based upon system records at the date of "project close". However, this resulted in some replacements not being captured when they were "capitalised" after this date. This affected the telecommunications replacements most significantly as these are typically capitalised after project close.

The table below shows the reconciliation between RIN volumes and those used in the calibration model.

Table 7 Reconciliation of replacement volume reported in RINs

	Average 2008/09 to 2013/14	
	Substation secondary systems	Telecommunication systems
RIN	78.5	42.7
Adjustment	-15.5	26.7
Calibration volume	63.0	69.3

Powerlink has used a different approach to set the life for the metering asset category. For this asset category Powerlink is not anticipating the need to replaces any meters due solely to their age and condition. However, Powerlink usually replaces aged meters in circumstances where most of the other secondary systems in a substation are being replaced.

Therefore, the metering asset life in the forecast model has been set to ensure that the number of metering replacements forecast by the model reflect the estimated quantity of major substation secondary replacements as predicted by the substation secondary systems asset category. This estimated quantity is calculated based upon the ratio of total meters to total substation secondary systems (i.e. bay plus non-bay systems).

- *meter replacements = forecast substation secondary systems replacements * total meters on network / total substation secondary systems on network*.

The table below summarises the secondary system replacement lives derived by Powerlink based upon this approach.

Table 8 secondary system replacement lives

Asset category	Replacement life
Substation	25.7
Telecommunications	20.7
Metering	28.8

3.4.3.2 Review discussion – secondary systems

Substation and telecommunication secondary systems

In Section 2.2 I noted that the secondary asset class is a significant asset class (as a proportion of repex). I also noted that Powerlink is forecasting a large reduction in replacement volumes for substation secondary systems, but a large increase for telecommunication secondary systems. Furthermore, in Section 3.3.4 I noted the inconsistency between the forecasts produced by the calibration model and forecast model for these two categories.

The reasons for these results can be understood from the two figures below. These figures shows 2014 age profile in the forecast model for the substation and telecommunications asset categories. They also show the inferred replacements that occurred over the calibration period by subtracting this 2014 age profile from the 2009 age profile used in the calibration model.

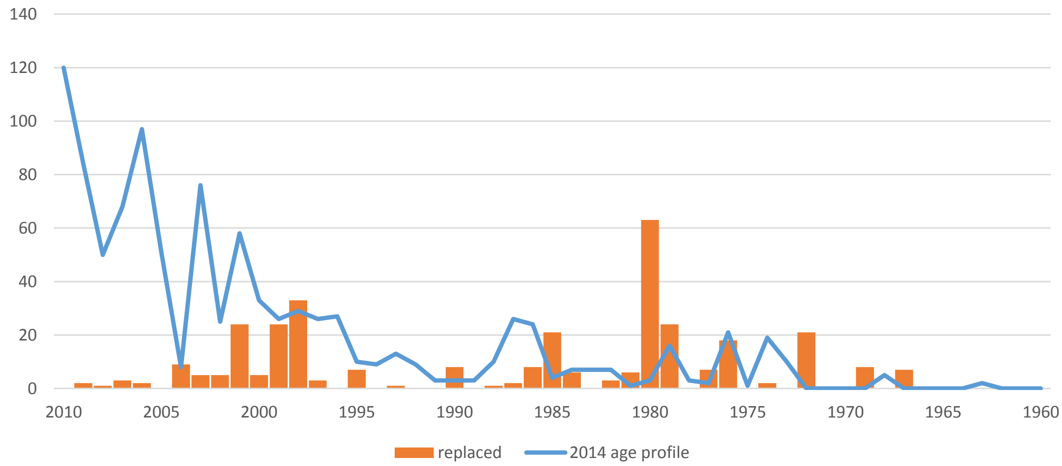

Figure 1 substation secondary system age profile and replacements

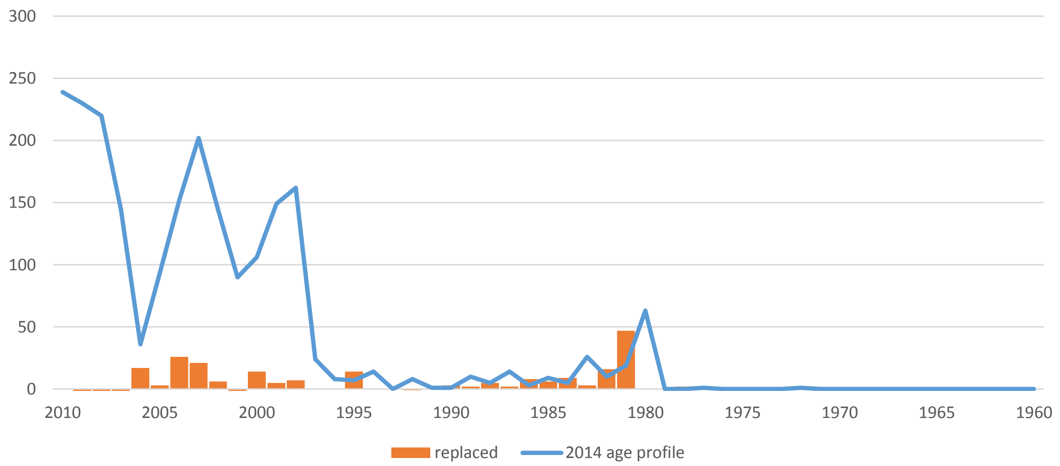

Figure 2 telecommunication secondary system age profile and replacements

For the substation category, which has a replacement life of 26 years, the forecast model is forecasting the need to replace the older assets, but this declines very quickly such that replacement volumes are low over the next regulatory period. The replacement of the large population of newer asset only increases after this period.

For the telecommunications category, which has a shorter life, the large population of newer assets dominate the replacements at an earlier time, resulting in a forecast increase over the next regulatory period.

These figures also suggest what is causing the inconsistency between the calibration model and forecast model. The replacement profiles in both figures indicate that at least two different replacement mechanisms may be occurring: one replacing the older population of assets and the other replacing the newer population. The calibration process is setting the mean life somewhere in the middle of this, but the standard deviation assumption means this model is not accurately reflecting these two mechanisms.

From a practical point of view, this aligns with my expectations for these types of asset category, where I would expect that technology changes will have significantly impacted the assets in these categories and their lives. Most notably, older protection and control schemes in the substation category would be of an electro-mechanical and analogue electronic form, whereas newer schemes will be micro-processor based. These two technologies should have significantly different lives.

To investigate the possible significance of this issue, I have split the 2009 and 2014 age profiles of these two categories into two: one covering “old technology” (installed prior to 1990) and one covering “new technology” (installed after 1990). I have also estimated the assets replaced over the calibration period for these two profiles, using the replacements indicated by the difference of the two age profiles.

From this I have recalibrated the lives for the new and old technology, using the calibration model and the revised 2009 age profiles. These lives are shown in the table below, compared to the Powerlink lives. The lives produced through these alterations seem to accord in a broad sense with what I would expect, which provides some comfort that this alteration may be appropriate.

Table 9 comparison of tower refit lives

	replacement lives		
Asset category	Powerlink	old technology	new technology
Substation	25.7	33.7	17.4
Telecommunications	20.7	33.9	17.1

I have then used these lives in a forecast model, using the revised 2014 age profiles. This alteration results in a significant increase in the forecast (see Table 10), particularly with substation secondary systems where more of the replacement of the newer technology is forecast to occur over the next regulatory period. This variation to the model also shows a much better consistency between the calibration and forecast models.

Table 10 comparison of secondary replacement forecast (2018 to 2020)

Asset category	average volumes per annum Powerlink	Nuttall Consulting
Old technology		13
New technology		57
Substation	**28**	**70**
Old technology		14
New technology		150
Telecommunications	**106**	**164**

Given the potential significant increase suggested by my investigations, I have discussed these concerns with Powerlink. Powerlink has indicated in discussions that it is not anticipating to replace this volume of secondary systems. However, this issue has raised concerns with Powerlink that the age profile may be incorrectly showing older asset that have already been replaced. If this is the case then the above may no longer be appropriate, and it is simply an error in the age profiles causing the inconsistency.

Whether or not there is an error, it could be that there still needs to be more than two asset categories to model newer technology in order to better represent Powerlink's expectations. For example, if the new assets had a cohort with a shorter life that was largely replaced in the calibration period then this may have artificially reduced the life assumed for the remaining newer assets, causing the model to predict the need for their replacement earlier than necessary.

Powerlink will need to investigate these matter further. This may require a review or audit of the age profiles and replacement volumes to confirm they are correct and consistent. It may also require the engineering analysis to be examined to better understand what is driving the need to replace the newer assets and whether the model is accurately reflecting this.

Metering

With regard to the method applied by Powerlink to prepare the metering forecast, this appears to be an "artificial" use of the repex model. As I understand it, the forecast is calculated essentially outside the model, albeit using model results from other modelled categories. This is because it is the replacement of these other asset that drives the need to replace meters, not the condition of the meter itself. As such, the metering life is simply set to ensure the model produces this required forecast – it is not expected to represent the true economic life of the meters.

Although, from a formulaic point of view, I see nothing wrong with this approach. Powerlink will need to take care that this is adequately explained, as the modelling and meaning of the meter life in the repex model could easily be misunderstood. Powerlink could even consider whether it should directly model metering as an asset category in the model. Instead, it could leave the calculation completely outside the model to avoid potential confusion.

3.4.4 Buildings and site infrastructure

3.4.4.1 Appreciation of approach

Asset categorisation

The forecast model uses four asset categories to represent the buildings and site infrastructure asset class, classified as:

- Substation or communications assets to allow for differences in the replacement unit cost parameters
- buildings or site infrastructure to allow for differences in the asset life and unit cost parameters.

Life calibration method

Powerlink has used the calibration model to calculate the lives for the substation buildings and substation site infrastructure categories. The volumes reported in the RINs for these two categories have been used to calibrate their lives.

These substation calibrated lives are then used for the equivalent communication buildings and site infrastructure categories. The underlying assumption here is that the lives should be very similar between substation and communications buildings and site infrastructure.

Powerlink has advised that it did not combine the substation and communication classifications because it did not explicitly report replacements of its communication buildings and communication site infrastructure historically[21].

The table below summarises the building and site infrastructure replacement lives derived by Powerlink based upon this approach.

Table 11 secondary system 49replacement lives

Asset category	Replacement life
Buildings	30.1
Site infrastructure	48.1

3.4.4.2 Review discussion – buildings and site infrastructure

In Section 2.2 I noted that the buildings asset class is the least significant asset class, representing only 8% of the repex forecast produced through the repex model. However, in Section 3.3.4 I noted the inconsistency between the forecasts produced by the calibration model and forecast model for these two categories, particularly with respect to the building asset category.

[21] Powerlink has advised that, historically, repex associated with these activities has been allocated to the "Other" replacement category.

This inconsistency concerned the forecast model predicting replacement volumes at a significantly higher level than the calibration model, over the equivalent period (2015 to 2022).

I have review the models to better understand the reasons for this inconsistency. My investigation suggest that this may be due to either an error in the age profile for this asset category or an error in the reported volume of replacements.

In support of this view, it is noticeable that the forecast model and calibration model produce very similar profiles of replacement volumes when referenced back to their base years (see Figure 3). This suggests that the forecast model is having to replace asset that the calibration model is predicting will already have been replaced. The increase in the forecast model at the beginning of the forecast period is because these assets are 5 years older in the forecast model. This suggests that there is an inconsistency between the age profiles used in the two models and the historical replacement volumes that have been used to calibrate the life.

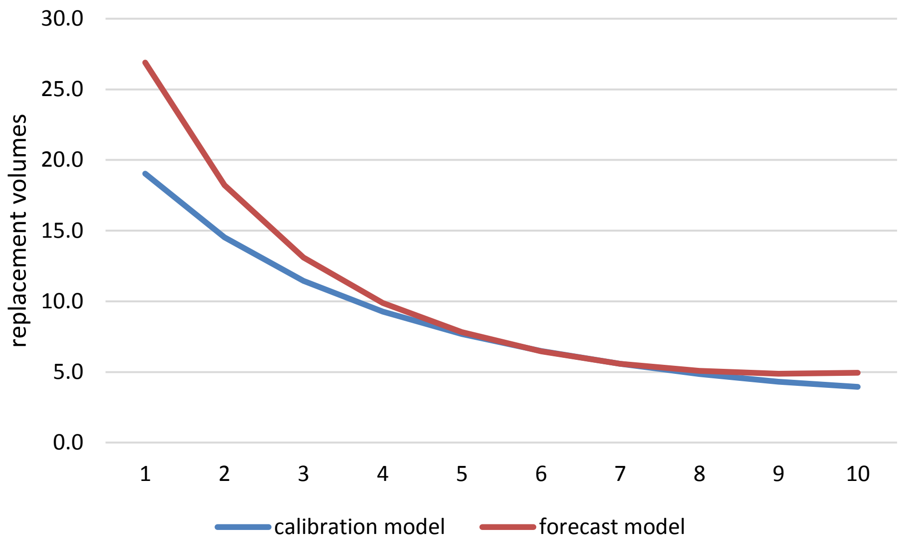

Figure 3 buildings - comparison of model forecasts

This inconsistency can also be seen in the figure below, which shows the 2014 age profile and inferred replacements (calculated by subtracting the 2014 profile from the 2009 profile) for the substation building category. This indicate that there is very little difference between the two profile, suggesting very few older building were replaced between 2009 and 2014. However, this finding contradicts the actual replacement volume, 40, which is used to calibrate the life.

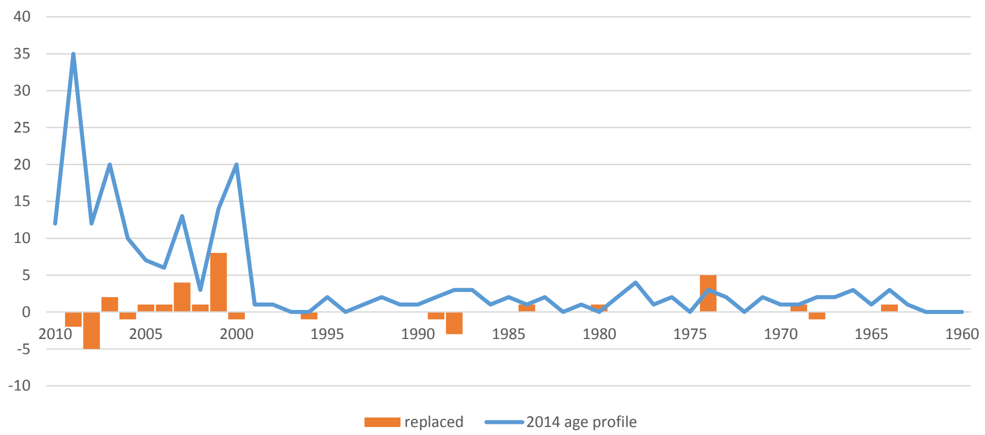

Figure 4 buildings age profile analysis

It is difficult to say what the effect of this could be on the forecast, as this depends on whether the error is in the 2009 profile, the 2014 profile, or the replacement volumes. Powerlink will need to investigate this matter to determine what is causing this inconsistency, and correct the model.

3.5 Summary of key findings and conclusions

I consider the repex model to be an appropriate method for preparing the replacement forecast for many asset classes, for these regulatory purposes:

- I do not consider that alternatives, based on more complex DEA method, are clearly a better method for forecasting replacement capex for these purposes.
- The AER repex model (or similar) with suitable application can address some of the potential accuracy shortcomings of the DEA method
- Forecasting through the AER repex model should reduce the effort associated with conducting the revenue reset process – both for the NSP and the AER
- I see no clear reason why the adoption of this method over DEA would hinder the AER's assessment process
- Powerlink has advised that it has processes in place to ensure the forecast produced by the model does not contradict the asset management plans it has developed through its engineering analysis. That is, where the model predicts significant movements up or down in future replacement volumes this movement corresponds with its expectations for that asset class.

To a very large extent, I consider that Powerlink has set up and implemented its repex models appropriately. In this regard, in most cases, the asset categorisation in the model and the method it has applied to calibrate the lives is appropriate, and is broadly in accordance with the approach the AER has applied to prepare an intra-company benchmark forecast (for replacement volumes).

There are some differences in how Powerlink has applied the model, but I agree with Powerlink that these can be characterised as "enhancements" as they should improve the accuracy of the forecast. Most notably:

- additional asset categories have been added to better capture variations in asset lives and unit costs, and in turn improve the accuracy of the model forecast
- assets have been removed that are forecast through Powerlink's "bottom-up" methodology or are planned to be decommissioned
- a repex model using 2009 age profiles has been used to more accurately calibrate the asset lives to replacement outcomes that have occurred between 2008/09 and 2013/14
- adjustments have been applied to RIN data (age profiles and historical replacement volumes) to account for discrepancies in reporting methods, correct minor data errors, and adjust the data to make it more applicable to the repex model.

I do however have some concerns with the modelling in some instances. Some of these concerns relate to the set up and implementation of the models, but others appear to be errors in the input data. My two most significant concerns relate to the towers and the secondary systems asset classes, which together represent a large portion of the repex forecast produced by the model.

- For towers, I am concerned that Powerlink's approach to deriving the lives for tower types that have not historically been replaced (or refit) in great numbers (i.e. towers in corrosion zones B and C) may be resulting in lives that are too short.
- In the case of secondary equipment, I am concerned that asset age profiles suggest that the model may not be set up correctly or there is an error in the age profile data.

The above two concerns have the potential to result in significant changes to the forecast. However, they will act in opposite directions: the tower forecast will reduce but the secondary category will increase.

In addition to the above, I have noted the following concerns that may have a smaller effect on the forecast:

- In addition to the possible error in the secondary system age profiles noted above, this review has also found possible errors in age profiles for CTs and buildings.
- The replacement of CTs associated with dead-tank circuit breakers may be modelled incorrectly, whereby the breaker life may be more appropriate than the CT life for signifying the need to replace.

It is important to stress that I am not recommending that these concerns mean the forecast is wrong and must be changed. Rather these matters may need to be investigated further to determine whether errors can be corrected and the models revised. In cases such as towers, if the model still conflicts with Powerlink's expectations and the life offset assumptions are considers to be correct then it will need to ensure that these assumptions are robustly supported by asset management information.

In addition, given the issues with a number of age profiles, Powerlink could consider implementing some form of audit process to provide a level of assurance that these age profiles and historical replacement volume data are accurate and fit for purpose. It is assumed that this could be built into the audit processes that are already defined for the data reported in the RIN.

I have also noted a number other matters through this review that Powerlink may wish to consider further:

- The unit costs in the model reflect Powerlink's estimates of its forecast unit costs. From the models and data provided I am unable to say whether these are above or below historical costs (as could be derived through the RIN data). This is likely to be a consideration of the AER, and so, Powerlink may need to investigate whether it can demonstrate this matter.
- I note that Powerlink has used 6 years of historical data to calibrate the lives. This differs from the AER approach, which has used 5 years previously. This assumption is not necessarily incorrect, but Powerlink may need to examine the effect of using a 5-year period and if it results in a significantly different forecast then it may need to justify its reasoning for adopting the 6-year period.

More detailed discussions on the above are provided in the review sections above.

Finally, it is worth noting that the AER is likely to have limited time to review these models and supporting documentation. It is highly unlikely it will engage with Powerlink to the extent I have in this review to address matters it does not understand sufficiently. Therefore, it will be critical that the final models and documents are presented as clearly and simply as possible. In the drafts under review here, there are many categories and calculations that are not relevant to the final forecast. Furthermore the calibration and forecast model are not linked together. This all has the potential to cause confusion to a reviewer. In addition, ideally workbooks should be produced that clearly show the reconciliation between age profiles and replacement volumes used or forecast in the model, and those provided in the relevant RIN tables.

4 Review of Powerlink's capex base-step-trend approach

In this section, I discuss my review of Powerlink's capex base-step-trend approach. As noted in Chapter 2, this approach has been used by Powerlink to produce the capex forecast for the following expenditure categories, which are within the scope of this review:

- replacement capex that is not forecast through the repex model or its bottom-up analysis (non-modelled repex)
- security and compliance capex
- other network capex.

I first set out my appreciation of Powerlink's application of this approach. Following this, I discuss my views on the appropriateness of this approach, including my views on the significant changes I highlighted in Chapter 2.

The section concludes with a summary of the key findings of this component of my review.

4.1 Appreciation of approach

The forecasts for the three expenditure categories under review have been prepared separately, but using the same methodology. This method can be understood in terms of the following three stages:

- Base - preparing the base line expenditure
- Trend – trending forward over the forecast period from the base line expenditure
- Step – adding forecast steps changes to the forecast trend.

4.1.1 Base

The base line expenditure for each expenditure category is developed from historical expenditure allocated to the category, covering the 8-year period from 2007/08 to 2014/15. This historical expenditure is built up from capex of the individual projects that have been allocated to that category.

The base line expenditure is calculated from this historical expenditure by excluding certain projects identified using two approaches:

- Significance – Very high cost projects, identified where the project cost is more than two standard deviations above the mean project cost in that category (2-SD test), are excluded.
- Non-recurrent – Powerlink has reviewed the remaining projects in the category to exclude projects that Powerlink considers are "one-offs".

4.1.2 Trend

Two methods are used by Powerlink to trend forward over the forecast period from the base line:

- Average - The mean annual expenditure of the base line is used to trend forward for non-modelled repex and the other network capex categories.
- Linear trend – A linear trend (using excels "Trend" function) is used to project forward for the security and compliance capex category.

4.1.3 Step

The capex associated with large "one-off" projects that Powerlink has planned for the forecast period are then added to the trend to produce the final forecast. It is understood that the need, timing and capex forecast for these projects has been determined by Powerlink from its bottom-up analysis process.

4.1.4 Forecast overview

Table 12 Summary of base-step-trend forecast

	Average per annum $ millions (real 16/17)		
	Replacement	Other Network	Security/compliance
Raw	**4.9**	**9.1**	**6.9**
Base	3.5	4.0	5.0
Trend	-	-	1.6
Step	-	2.3	-
Forecast	**3.5**	**6.3**	**6.6**

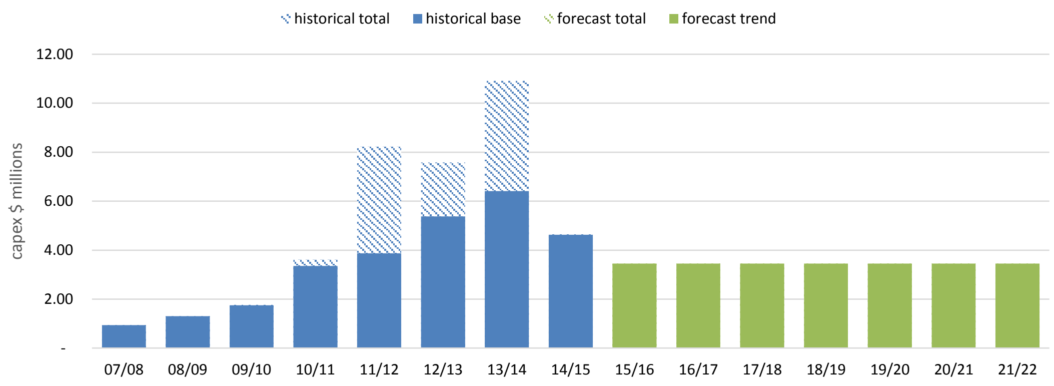

Figure 5 non-modelled repex base-step-trend forecast

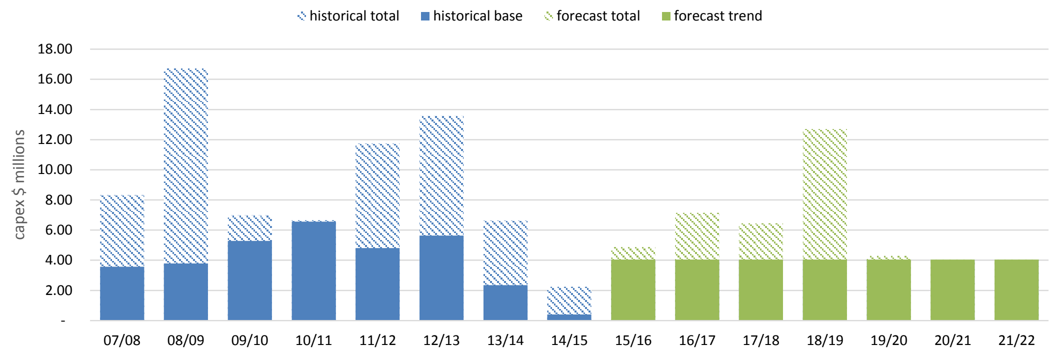

Figure 6 other network capex base-step-trend forecast

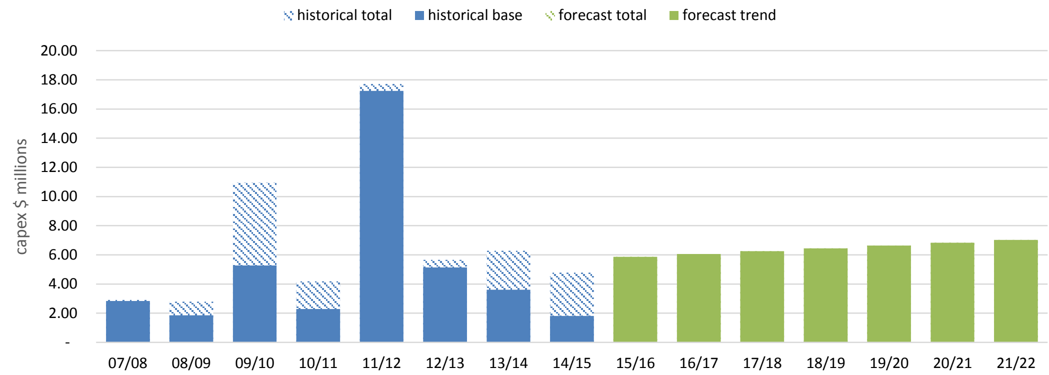

Figure 7 security and compliance base-step-trend forecast

To provide further context to my review discussion below, Table 12 summarises the development of the forecasts for the three expenditure categories, based upon the draft forecast provided for this review. This table shows the average capex (per annum) associated with the various stages of the forecast development. Figure 5 to Figure 7 show the annual profile in expenditure for each of the three capex categories.

This table and the figures indicate the following:

- Exclusions to the base – All categories have a material portion of historical expenditure excluded to produce the base line. The most notable excluded projects are:
  - Other network capex – Establishment of DWDM network ($19 million), MPLS wide area network deployment stage 1 ($12 million), spare transformers ($9 million)
  - Non-modelled repex – operational support systems for telecommunications ($6 millions), diesel generator installation ($5 million)
  - Security and compliance – disaster recovery relocation ($7 million), substation security upgrade stage 1 ($8 million)
- Trend – The use of the linear trending method for the security and compliance category is resulting in an increasing level of expenditure over the forecast period from the base-line.

- Steps – Only the other network capex has a step change added to the forward trend. This step change covers the following planned projects:
  - accurate fault location system stage 3 ($7 million)
  - wide area network deployment stage 2 ($6 million)
  - system spare transformer second 132/66 kV ($3 million).

4.2 Review discussion

4.2.1 Suitability of a base-step-trend approach

In the context of how Powerlink has advised that it is preparing its capex forecast, I consider it the base-step-trend approach adopted by Powerlink to be a suitable method to prepare regulatory forecasts for these three expenditure categories. To support this view, I make the following observations:

- As noted in Section 2.2, these capex categories represent a small portion of the overall non-demand-driven capex forecast. Furthermore, they have asset types and activity drivers that can be harder to model by "predictive" forecasting methods, such as the AER repex and augex models, or similar models. Therefore, it is reasonable to consider a simplified approach, such as historical trending, to produce the forecast for these categories.
- From my experience of conducting reviews for the AER, this approach is similar to historical trending approaches I have seen many other NSPs use for similar capex categories. Historical trending is also a method I have used during these reviews to produce an alternative forecast for low significance expenditure categories, when I have rejected the NSPs forecast.
- In recent decisions (including draft decisions), the AER has accepted these forecasting methods, or used a similar method to derive an alternative forecast, for similar capex categories[22].
- In the methods noted in the points above, typically a simple historical average is applied. I note that Powerlink has "enhanced" its method by excluding very large and one-off projects from the calculation of the trend, but adding in large planned projects to the forecast trend. This approach has resulted in a reduced forecast from the simple historical trend, which supports a view that Powerlink has not applied these enhancements to systemically bias the forecast.

It is worth noting that there could be an argument that if Powerlink has significantly changed its risk position over the historical period, used to prepare its base, then this method will result in a projection of this movement. This would not be in accordance with the capex objectives for regulatory forecasts set out in the Rules. For example, if Powerlink has improved its reliability, safety, and/or security then this method could produce a forecast

[22] For example, see Attachment 6 – Capital Expenditure, AER preliminary decision for SA Power Networks, April 2015, and the AER's rationale for elements of the replacement forecast not assessed through the repex model.

that allows for a continuations of this improvement. This argument is valid. However, in my experience, for capex forecasting, an adjustment for this would not be applied directly through this methodology as it would be very difficult to isolate the portion of such a change to the specific asset categories being forecast or projects in the base. Instead, should Powerlink consider that this is relevant, then a top-down adjustment of some form may need to be applied across the forecasts. The methodology for estimating such an adjustment is outside the scope of this review.

4.2.2 The application of the base-step-trend method

The raw project costs data

In this method review, it is not possible to assess in detail whether specific projects have been allocated to these categories correctly. I *have* undertaken a high-level review of the project description in the data files[23], purely to confirm that Powerlink's explanation of the expenditure categories aligns with the projects allocated to it. This has not found anything to raise concerns that the projects are not valid for the allocated categories.

However, I have noted through this review that there is scope for projects to be misallocated or potentially double counted. For example, many of the projects in the other and non-modelled repex categories could be viewed as secondary systems. Furthermore, Powerlink has advised that it has not been possible to reconcile this historical data to its category analysis RIN's. On this matter it has stated:

"*Capital expenditure in the major categories such as augmentation, connection, replacement and non-network have been reported within the RIN on an as-commissioned basis, not an as-incurred basis. Powerlink's forecasting approach for the Revenue Proposal is based on forecasting capital expenditure on an as-incurred basis.*

Capitalised expenditure is reported in the RIN in the year in which an asset is first capitalised. In many cases the project continues on beyond this initial capitalisation year and additional project common costs are added to the assets initial value. These later year costs are included in the balancing item at the bottom of the RIN Repex Table as post-commissioning costs. This balancing item also includes those costs for assets which are not captured within the Repex modelling.

Table 2.1 of the Category Analysis RIN reconciles the various categories of as-commissioned capital expenditure to a total of as-incurred capital expenditure. However it does this via a single balancing item which includes the as-incurred expenditure for the Security / Compliance and Other categories as well as balancing the total as-commissioned to the total as-incurred across all other categories of expenditure.

As part of the Revenue Proposal Powerlink intends to provide historical capital expenditures on an as-incurred basis for each category. This will reconcile with the capital expenditure by category that Powerlink reports to the AER as part of the annual Regulatory Accounts, however the Regulatory Accounts are not published by the AER."

[23] Note, these are very brief descriptions, typically representing a long form project title. There are not detailed descriptions of the project.

I consider it would be reasonable for the AER to require some form of assurance that the costs have been allocated correctly to these three categories and they are not being double counted (at least party) through other forecasting methods. Therefore, Powerlink may need to consider whether it is feasible to conduct some form of audit of a sample of the projects in each category to provide a level of assurance that they have been allocated correctly, and they do not contain activities/costs that are being forecast elsewhere. Ideally, this would be supported by also providing some clear reconciliation of these costs to the category analysis RIN – or vice versa. Give the low significance of the forecast, it may be that a fairly coarse assurance is all that is necessary here.

Baseline exclusions

I agree with Powerlink that the correct application of the base-step-trend method for capex exclusions would need to remove very large projects that will affect the calculation of a trend, and one-off (or very infrequent) projects that should not be included in a short term projections. This is particularly important when also adding planned projects as step changes to the trend.

With regard to Powerlink 2-SD test, it is important that I stress that I am not claiming expertise in statistical analysis. As such, I cannot define what an accurate and suitable outlier test would be for these circumstance. Nonetheless, I will make the following observations on this matter. Many tests have underlying assumptions about the distribution of the data. I am not sure if these will be valid for these circumstances, as Powerlink has as much control of the distribution of costs as random factors will influence them. For example, Powerlink can decide to group or stage projects to affect the distribution of costs.

Furthermore, from my quick analysis of the data, the often assumed normal or lognormal distributions were not obvious. Therefore, I think it may be difficult to define some form of confidence level around the accuracy of the base-line, when using a formulaic method to identify outliers.

As such, I consider Powerlink's 2-SD test to be a reasonable approach to perform as a "first sweep" to identify potential significant outliers. However, this should be is supported by a more heuristic approach to identify projects (or groups of similar projects). Powerlink has applied a form of this to identify its off-off projects to exclude. However, I am concerned that it has not performed a more visual inspection of the resulting cost profile to decide whether some other underlying factors may be inappropriately affecting the base-line expenditure.

Based upon the three figure above, the non-modelled repex and other network capex exhibit a reasonable profile that "visually" looks suitable for trending. However, the security and compliance category still has a significant spike in the costs in 2011/12. This could suggest that exclusions have not been applied appropriately for this category.

From an examination of the projects, this is due to six project, which appear to be two programs:

- Secure Tower Bolts (South East Urban Region)

- Secure Tower Bolts (South Western Region)
- Secure Tower Bolts (NW Southern Region)
- Transmission Structure Signs Upgrade (Southern)
- Transmission Structure Signs Upgrade (Northern)
- Transmission Structure Signs Upgrade (Central)

Together these projects sum to $12.6 million in 2011/12, representing a large part of the spike. It is not clear why together these projects should not be treated as either very large or one-offs, and excluded from the base line. If that was the case then this would have a significant effect on the base-line and the trend moving forward (assuming the linear trend). This is shown in the figure below where I have excluded these projects and recalculated the trend. This represents a significant reduction of 66% from the original Powerlink forecast.

Powerlink will need to reconsider these historical projects to decide whether together they should be excluded from the base. If this is not the case then Powerlink will need a good justification for why they represent such a spike in one year and yet it is still reasonable to assume expenditure of this nature can be trended forward. On this, it is worth noting that their exclusion from the base will mean that Powerlink should reconsider whether a step change is then necessary to allow for planned works of a similar nature that it is presently assuming to be covered by the trend. As such, the reduction due to the alteration may not be as significant as suggested here.

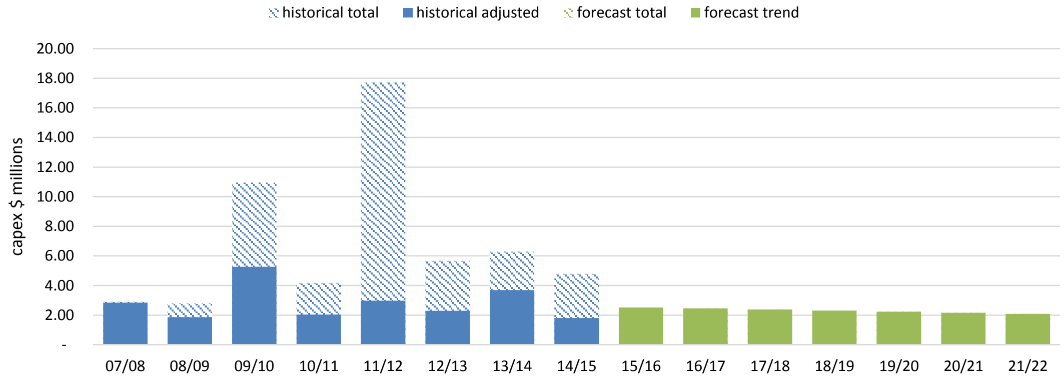

Figure 8 Adjusted security and compliance base-step-trend forecast

Trend

Noting my point above that the NSP has significant control on the costs in an asset category, my preference would be to use the average of the base line to represent the trend forward from the base line as this is a fairly neutral assumption. If a trend up or down from the base line is assumed then the underlying mechanism causing the change should be explainable.

Given this, I consider the averaging method used to form the trend forward for the non-modelled repex and other network capex categories is a reasonable assumption. I note that there is quite a pronounced trend up in the historical capex in the non-modelled repex category (see Figure 5). However, if the continuing trend was as significant as suggested by this then I would expect that the underlying mechanism driving this pattern should be understandable and modellable. Therefore, an alternative method, such as a predictive model like the AER repex model, would be more appropriate for producing a forecast in this circumstance. However, given a) Powerlink has not provided any reasoning to consider such a mechanism exists for this category and b) Powerlink's repex modelling and bottom-up analysis is not indicating increases in repex are necessary in other areas, I do not consider that this historical pattern means an alternative forecasting method or alternative trend assumption would be preferable.

Given this rationale, I have concerns with Powerlink's decision to use of a linear trend for security and compliance, particularly noting this causes an increase in the forecast over the base-line. This will have different underlying drivers than repex, so the repex pattern is no proxy for a possible pattern in this category. Nonetheless, I do not think this pattern is clearly evident from the historical data, particularly if the spike in 2011/12 is discounted. Interestingly, if the adjustment to the base discussed above is applied then the linear trend changes direction, and trends down slightly over the next period.

Therefore, I consider that the average base-line capex is a more suitable assumption for the security and compliance category, unless Powerlink can produce a compelling argument why the linear trend is more appropriate. This reasoning should correspond with the final direction of the trend.

Step

I note that only the other network capex has capex associated with three planned projects added to the trend as step changes. I am not in a position to say what step changes should be added in, as I am not aware of Powerlink's asset management plans. However, from the identifier of the projects, two projects look consistent with projects excluded from the base-line, namely the wide area network deployment project and spare transformers projects are excluded from the base line and added to the trend.

The other project is a large stage of a project to implement a fault locating system. It is noted that earlier stages of this project are left in the base – although, these are of a much smaller value ($1.5 million in total compared to $7 million). Nonetheless, there could be some argument that this means that this portion of the planned stage is already allowed for in the base.

Powerlink may need to reconsider these historical elements of this project to determine how they relate to the planned stage, and whether they should also be excluded from the base line.

4.3 Summary of key findings and conclusions

I consider the base-step-trend method to be an appropriate approach for preparing the forecast for these three non-demand-driven capex categories, for these regulatory purposes. The categories represent only a small portion of non-demand-driven capex and so a simplified approach should be suitable. Furthermore, this approach is similar to what the other NSPs and the AER has used to prepare forecasts for these types of category.

To a very large extent, I consider that Powerlink has implemented this approach appropriately. I do however have some concerns.

My most significant concern relates to the exclusions applied to the security and compliance category to calculate its base. After allowing for these exclusions, the base still shows a very significant spike in 2011/12, which relates to two large programs of works that have been split into smaller projects. If these programs are excluded then the base looks more uniform and the resulting trend forward is much lower. That said, it is not clear whether the exclusion of these programs from the base would require a countervailing change to the forecast by adding similar planned programs as step changes.

In addition to the above, I have concerns with the following two matters, which are less significant on the resulting forecast:

- I consider the historical average may be a more appropriate assumption for the security and compliance category, rather than a linear trend - unless Powerlink has a compelling argument for the suitability of the linear trend.
- For the other network capex category, the fault location system project is added as a step change, but earlier stages of this project are not removed to produce the base.

Powerlink will need to consider these matters further and decide whether an alteration to its forecast is necessary.

Finally, it is worth noting that Powerlink has advised that it is difficult to reconcile the historical costs used to produce this forecast with expenditure reported in the category analysis RINs. I consider it would be reasonable for the AER to require some form of assurance that the costs have been allocated correctly to these three categories and they are not being double counted (at least party) through other forecasting methods. Therefore, Powerlink may need to consider whether it is feasible to conduct some form of audit of a sample of the projects in each category to provide a level of assurance that they have been allocated correctly, and they do not contain activities/costs that are being forecast elsewhere. Ideally, this would be supported by also providing some clear reconciliation of these costs to the category analysis RIN – or vice versa.

More detailed discussions on the above are provided in the review sections above.

2 Capability

2.1 Nuttall Consulting

Nuttall Consulting has provided services to the electricity industry and related government agencies since 2005. It focuses on drawing together its technical and engineering knowledge of the electrical industry with relevant regulatory, commercial and energy policy matters. Services provided to clients have ranged from strategic advice on regulatory frameworks associated with the electricity network businesses to detailed reviews of individual investment projects for revenue/price setting purposes.

Nuttall Consulting has significant experience with the AER's repex model, which makes it particularly suited to providing the services required by Powerlink. Most notably, Nuttall Consulting was engaged by the AER to:

- develop the AER's repex model application
- apply the repex model in the last Victorian and Tasmanian DNSP determinations
- provide advice on the data requirements and applications of the model, as part of the AER's preparation of its EFA Guideline and Regulatory Information Notice (RIN) templates
- present in numerous AER workshops on the application of the repex model.

Most recently, Nuttall Consulting has been engaged by two Victorian DNSPs to undertake repex modelling in order to provide supporting documents for their regulatory proposals.

Additionally, Nuttall Consulting has been engaged by the AER on numerous occasions to provide advice related to its regulatory determinations and has been engaged by network businesses to advise on the preparation of their regulatory proposals. This has provided Nuttall Consulting with significant experience with:

- a broad range of capex forecasting methods used by network service providers, both bottom-up and top-down
- the AER's expenditure assessment techniques and their application
- the application of the National Electricity Rules with regard to assessing expenditure and preparing documentation suitable for regulatory purposes.

2.2 Proposed personnel - Brian Nuttall

Brian Nuttall is the director of Nuttall Consulting and will be responsible for all activities defined in this proposal.

Brian Nuttall has a PhD in electrical engineering and is based in Melbourne, Australia. He has nearly 20 years' experience consulting to government agencies, energy businesses and other industry stakeholders. He has worked as a consultant specialising in electricity regulation, strategy and asset management for the past ten years after beginning his career as a power system studies engineer within a large consulting engineering firm.

As part of the Nuttall Consulting experience noted above, Brian acted as the lead consultant and project manager for all assignments. Most notably, Brian was solely responsible for all the repex model engagements with the AER and the Victorian DNSPs discussed above.

In addition to the above, through his former employer (PB Power), Brian has been responsible for many other similar review and modelling exercises, both on behalf of regulators and DNSPs.

This experience means that Brian is familiar with all aspects relevant to providing the services, including:

- the data and systems that be may use to prepare inputs for these types of model
- the application of the AER models
- the regulatory principles underpinning the models
- the relevance of these models to other top-down and bottom-up forecasting techniques
- the technical/engineering principles that may underpin the capex forecasts
- interacting with both a technical and regulatory audience
- the preparation of documents for regulatory purposes.