2018-22
POWERLINK QUEENSLAND REVENUE PROPOSAL

APPENDIX 5.05

Powerlink Queensland
Non-Load Driven Network Capital Expenditure
Forecasting Methodology

Delivering better value

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Executive Summary

In developing capital expenditure forecasts for the 2018-22 regulatory period Powerlink has moved away from using a primarily bottom-up approach to developing expenditure forecasts. For the most substantial category of capital expenditure, network reinvestment, Powerlink has made use of the Australian Energy Regulator's (AER) Replacement Capital Expenditure Model (Repex Model).

This Non-Load Driven Network Capital Expenditure Modelling Methodology sets out the key modelling approaches, data inputs, and assumptions that Powerlink has applied to the Repex Model. It describes how Powerlink has modelled its actual asset management practices within the Repex Model framework. It also describes the trend based models that have been used to forecast some other categories of non-load driven capital expenditure. Finally, it describes the checks and validation that Powerlink has undertaken to ensure the resulting forecasts are reasonable.

The key inputs and assumptions to the Repex Model are in the following areas:

- Approach to calibrating the Repex Model;
- Development of asset age profiles;
- Historical replacement quantities; and
- Developing the overall forecast.

For some types of assets Powerlink is not forecasting any specific reinvestment needs and these have been excluded from the Repex Model. These categories include underground cables and reactive plant. Power transformer reinvestments, being low volume and high cost items, have been forecast outside of the Repex Model using a bottom-up approach.

Overview

In developing its methodology for applying the Repex Model to forecasting capital expenditure Powerlink has taken all reasonable steps to adapt the AER's Repex Model to reflect the real-life circumstances of Powerlink's asset base and prudent asset management practices. The adjustments that Powerlink has made to the Repex Model input datasets have had the effect of reducing the capital expenditure forecasts from what would have been produced from the raw datasets.

As part of Powerlink's business as usual stakeholder engagement activities, feedback was received from customers and consumers on some specific asset planning circumstances. Powerlink has been able to incorporate this feedback into the development of its modelling so that the resultant forecasts genuinely reflect the feedback and concerns received from stakeholders.

Powerlink sought independent advice from Nuttall Consulting on the suitability and robustness of this methodology for forecasting capital expenditure to meet the capital expenditure objectives in the National Electricity Rules. Nuttall Consulting considered that the Repex Model and trend based models developed by Powerlink were appropriate methods for preparing capital expenditure forecasts and that Powerlink had set up and implemented these approaches appropriately.

Forecasts from the Repex Model make up approximately 74% of Powerlink's total forecast capital expenditure while forecasts from the trend based models make up approximately 7%.

In summary, Powerlink considers that the combination of Repex Model and trend based modelling has produced a prudent, efficient and realistic forecast of required capital expenditure.

Approach to calibrating the Repex Model

Powerlink's overall approach has been to construct an asset age profile from an earlier year and then use the annual average replacement quantities from that time to the present to calibrate a set of mean replacement lives. These calibrated mean replacement lives have then applied to the current asset age profile to generate the forecast reinvestment quantities for each type of asset. This approach is intended to produce a forecast that is calibrated to both the drivers of the historical replacement volumes and the current state of those drivers expressed through the current age profile.

Powerlink has selected 30 June 2010 as the appropriate starting date for the historical asset age profile. This date allows the most recent five years of actual replacement data to be used to calibrate the model.

For the purposes of calibrating the Repex Model Powerlink has generally adopted the asset categories set out in the AER's Category Analysis Regulatory Information Notice. The exception is that for modelling purposes Powerlink has classified its transmission towers based on corrosion zones. These corrosion zones are characterised as moderate to very aggressive corrosion (zones D, E and F), mild corrosion (zone C) and very mild corrosion (zone B). Powerlink's approach to calibrating the expected replacement life for transmission towers has been to calibrate the actual replacement volumes in each corrosion zone separately.

Powerlink has three primary reinvestment strategies for transmission lines: replacement, refit (life extension), and decommissioning and disposal at end-of-life if there is no enduring need. The calibration methodology determines a mean life for the replacement strategy and Powerlink then models the refit strategy as an advancement of five years earlier than the end-of-life replacement timing. The five year average advancement maximises the effectiveness of the surface treatment to extend the life of the structures and reduces the risks in managing a large fleet of ageing transmission structures. Importantly, it achieves these outcomes at no increase in the long run costs to consumers.

Powerlink's asset management planning process has identified a number of network assets that could be retired from service at their end-of-life and not replaced, while the required levels of supply reliability and network security continue to be met. The most significant assets identified for retirement are transmission lines assets. Powerlink has identified a total of 2,725 transmission structures that could be retired in the future without reinvestment. As Powerlink does not intend to spend any capital reinvesting in these identified assets, they have been removed from the asset age profile. The removal of these assets from the age profile ensures that the Repex Model cannot forecast any capital expenditure in relation to these assets. Importantly, it does not mean that all of these assets will be retired within the 2018-22 regulatory period, only that Powerlink does not anticipate the need to reinvest in these assets in the future.

A similar approach to future retirements has also been adopted for other types of assets. Where Powerlink's asset management planning process has identified assets that could be retired from service at their end-of-life and not replaced, these have been removed from the Repex Model.

Periodically, asset transfers occur between Powerlink and Energex and Ergon. Where asset transfers occurred after the date of the 2010 asset age profile that is used for calibration, the age profile data was adjusted to account for the transfer.

Development of asset age profiles

In responding to the annual Category Analysis RIN Powerlink has already provided significant data of the type that will be used in the Repex Model. However, Powerlink has identified several aspects of the asset age profile data that have required adjustment in order to be suitable for use in the Repex Model.

For the substation switchbay equipment category Powerlink has provided data on a different basis between the asset replacement quantities and the asset age profile. The replacement quantities have been reported at the equipment level, being the number of individual circuit breakers (CBs), current transformers (CTs), voltage transformers (VTs) etc. The asset age profile has been reported by the type of switchbay based on a hierarchy of equipment installed. That is, if a circuit breaker is installed it is a CB bay regardless of the presence of any other equipment in that bay, if there is no CB but an isolator is installed then it is an isolator bay, etc.

For the purposes of the Repex Model Powerlink has chosen to model at the switchbay equipment level. Powerlink has therefore generated a new asset age profile from the source RIN data based on the age profile of all equipment, not just the type of switchbay.

In analysing the secondary systems asset age profile in the RIN data, Powerlink identified that a number of secondary systems assets had a recorded capitalisation date of 1 July 1996. This appears to be a default value set to the start of Powerlink's first full financial year as a corporate entity. Powerlink considers this data to be erroneous and for these assets has identified an alternative date based on the start-up date of the physical equipment.

The reported RIN data has a single category for the site infrastructure asset category and a single category for the buildings category. The site infrastructure category included data for both substation sites and dedicated communications sites, however buildings only includes data for substation site buildings. Powerlink has recognised that there is a substantial difference in scale between a conventional substation site and a dedicated communications site. Powerlink has therefore segmented the reported RIN data to split both site infrastructure and site buildings between substation sites and communications sites.

Historical replacement quantities

Generally the replacement quantities reported in the RIN data were appropriate for use in the Repex Model, however Powerlink has made some changes for the following reasons:

- Substation equipment quantities were originally reported based on procurement records. This has now been updated to use equipment records from Powerlink's Enterprise Resource Planning System (SAP) which is considered more accurate, reflecting the equipment actually installed rather than equipment purchased under a project which may include purchase of spares.
- Other adjustments made to the substation equipment replacement quantities reported in the RIN data were:
    - Removal of quantities associated with replacement volumes that are not expected to be relevant for future forecast quantities;
    - The quantity of CTs replaced by CTs within the dead tank circuit breakers have been added to the replacement CT quantities; and

- Where the replacement of equipment was not completely condition driven, for example replacement for safety reasons due to excessive fault level, that replacement quantity has been removed from the quantities reported in the RIN data.

For secondary systems and telecommunications assets the reported RIN data provided the total replacement quantities for all secondary systems assets under a single heading. For use in the Repex Model Powerlink has segmented the secondary systems assets into the following sub-categories:

- Bay secondary systems;
- Non-bay secondary systems;
- SVC secondary systems; and
- Metering assets.

Within each of these sub-categories, and together with telecommunications assets, Powerlink has identified several required adjustments to the replacement quantities. The most significant adjustment was where telecommunications assets were capitalised after the completion of projects and were not captured in the reported quantities in the RIN data.

Trend modelling

While the majority of non-load driven network capital expenditure has been forecast using the Repex Model there is some expenditure that has been forecast using trend based models:

- Reinvestment outside of the Repex Model;
- Security/compliance; and
- Other.

Forecast expenditure from these trend based models constitutes around 6.5% of Powerlink's total capital expenditure forecast.

The basis for using this form of model for forecasting capital expenditure is that there is a generally recurring level of expenditure in these categories that is necessary for the ongoing provision of prescribed transmission services.

The starting point for each of the trend models is the actual historical capital expenditure in that expenditure category for each year. Within each category of expenditure, analysis of individual projects has been undertaken to identify projects for which the historical expenditure should not form part of the base trend.

Once the non-recurrent expenditure in each category has been removed the resulting historical base expenditure is trended forward in time as the forecast base expenditure. Powerlink has used the annual average historical expenditure from 2010/11 to 2014/15 to generate this forecast.

Once a forecast base expenditure was developed any new non-recurrent or abnormal expenditure was added back on to the trend forecast.

Developing the hybrid forecast

Even for categories of expenditure where Powerlink is forecasting future capital expenditure using top-down models, there is already capital expenditure in those categories that has been approved on a bottom-up basis. The approach that Powerlink has adopted to model the transition from bottom-up forecasts to top-down forecasts is set out in the steps below:

- The approved capital expenditure budget for the current financial year (2015/16) is adopted;
- Beyond the current financial year each category of expenditure where top-down forecasting is applied is considered in turn – Reinvestment, Security/Compliance and Other;
- Within each category the forecast capital expenditure for each asset class – such as transmission lines, substation primary plant or secondary systems – is separately identified for both approved projects and the top-down forecast;
- For each year for each asset class in each expenditure category Powerlink has used the greater of approved project expenditure and the top-down forecast as the forecast for that year; and
- Where expenditure in an asset class for approved projects is greater than the top-down forecast in any year, an amount equal to the difference has been removed from the top-down forecast in adjacent years. This has been done so that the total forecast overall matches the top-down forecast.

The basis for this approach is that approved projects represent the most accurate forecast of future capital expenditure in any given year, as well as the most accurate forecast of the asset class breakdown.

As the capital expenditure forecasts produced by the top-down models are not limited to integer quantities of equipment Powerlink has interpreted these forecasts as being the capital expenditure as-incurred. Powerlink expects that most of the capital works program in the forthcoming regulatory period to involve the progressive reinvestment in existing assets on existing sites. In most instances new assets will be commissioned and capitalised towards the end of a project, consistent with Powerlink's current practice.

Powerlink's typical network project implementation incurs the majority of expenditure over a two year period following project approval. For this reason Powerlink is assuming that capital expenditure as-commissioned is generally recognised in the year following the capital expenditure as-incurred.

Powerlink has developed the Repex Model so that only integer quantities of asset or equipment reinvestment are recognised for commissioning in each year of the forecast. Any remainder from the integer quantity is then carried forward into the subsequent year and the process repeated. The one exception to this methodology is for transmission lines.

As Powerlink's unit of plant for transmission line assets is defined as a built section, the reinvestment in an asset is not completed until all structures in the built section have been refit or replaced. Powerlink has modelled the as-commissioned capital expenditure by accumulating the various forecast quantities for the different structure types from the Repex Model until there is sufficient number to match the oldest built section of that type. Once sufficient quantity has been accumulated the total capital expenditure for that quantity is recognised as the as-commissioned capital expenditure for that asset.

Checking and validation

Powerlink has undertaken a number of checks and validations for the capital expenditure forecasts produced from these top-down models to ensure they are reasonable. These checks have included:

- Comparing the calibrated replacement lives against industry norms;
- Comparing Repex Model unit costs against indicative bottom-up project estimates; and
- Comparing Repex Model quantities against Asset Management Plans.

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1 Introduction

As described in Powerlink's Expenditure Forecasting Methodologies[1], load-driven categories of capital expenditure have been forecast using a bottom-up approach based on individual estimates for specific projects. For the non-load driven categories of network capital expenditure, Replacement, Security/Compliance and Other, Powerlink has adopted a mix of both bottom-up and top-down forecasting methods. This document describes the methodologies, data and models that Powerlink has used to develop top-down forecasts of capital expenditure for a number of different elements of non-load driven expenditure.

In developing its forecasting models, Powerlink engaged Nuttall Consulting to review the approaches being adopted and provide independent advice on the suitability of the models for forecasting capital expenditure to meet the requirements of the Rules. Nuttall Consulting made a number of observations regarding how Powerlink was approaching the development and use of the forecasting models described in this document. These observations, and Powerlink's response to the opinions offered by Nuttall Consulting, are noted in the relevant sections of this document.

Powerlink has also developed these methodologies cognisant of the observations made by the AER in their Final Framework and Approach Paper for Powerlink[2].

1.1 Categories of expenditure

Consistent with the requirements of the National Electricity Rules (Rules), Powerlink has forecast capital expenditure with reference to well accepted categories of drivers of capital expenditure. Powerlink has retained the same categories of capital expenditure for the current regulatory period, except that the Replacement category has been renamed as Reinvestment to better reflect the nature of the activities undertaken in this category. The categories of expenditure and the forecasting methodologies to be applied to each category are set out in Table 1.

[1] https://www.powerlink.com.au/Network/Documents/Regulated_revenue/201718_–_202122_Revenue_Proposal_Expenditure_Forecasting_Methodology.aspx.

[2] *Final Framework and Approach for Powerlink for the regulatory control period commencing 2017*, AER, June 2015.

Table 1 Categories of capital expenditure

Capital expenditure category	Definition	Forecasting methodology
Network – load driven		
Augmentations	Relates to augmentations defined under the Rules. Includes projects to which the Regulatory Investment Test for Transmission (RIT-T) applies. Typically these include projects such as the construction of new lines, substation establishments and reinforcements or extensions of the existing network.	Bottom-up
Connections	Works to facilitate additional connection point capability between Powerlink and DNSPs. Associated works are identified through joint planning with the relevant DNSP.	Bottom-up
Easements	The acquisition of transmission line easements to facilitate the projected expansion and reinforcement of the transmission network. This includes land acquisitions associated with the construction of substations or communication sites.	Bottom-up
Network – Non-load driven		
Reinvestments (replacements)	Relates to reinvestment to meet the expected demand for prescribed transmission services. Expenditure is primarily undertaken due to end of asset life, asset obsolescence, asset reliability or safety requirements. A range of options is considered as asset reinvestments, including removing assets without replacement, non-network alternatives, line refits to extend technical life or replacing assets with assets of a different type, configuration or capacity. Each option is considered in the context of the future capacity needs accounting for forecast demand.	Top-down and bottom-up
Security/Compliance	Expenditure undertaken to ensure compliance with amendments to various technical, safety or environmental legislation. In addition, expenditure is required to ensure the physical security (as opposed to network security) of Powerlink's assets, which are regarded as critical infrastructure.	Top-down
Other	All other expenditure associated with the network which provides prescribed transmission services, such as communications systems enhancements, improvements to network switching functionality and insurance spares.	Top-down and bottom-up
Non-network		
Business IT	Expenditure to maintain IT capability and improve business system functionality where appropriate.	Bottom-up
Support the Business	Expenditure to replace and upgrade business requirements including the areas of commercial buildings, motor vehicles and moveable plant.	Top-down and bottom-up

1.2 Overview of forecasting models

Powerlink has developed two main top-down forecasting methodologies for the purposes of developing capital expenditure forecasts:

1. Predictive Modelling – based on the AER's Replacement Capital Expenditure (Repex) Model and which has been used to forecast the majority of capital expenditure in the Reinvestment category; and
2. Trend Modelling – analogous to the AER's base-step-trend approach for forecasting operating expenditure and which has been used to forecast capital expenditure in the Security / Compliance and Other categories as well as some expenditure in the Reinvestment category.

These two main forecasting methodologies are described in more detail in Sections 1 and 3 below.

In its Final Framework and Approach Paper for Powerlink the AER stated that it will "continue to expect that the major technique used in forecasting capex will be the 'bottom-up build'. However, the AER also tempered this statement by acknowledging that "a top-down estimating approach calibrated by reference to a sample of supporting bottom-up builds may offer scope to reduce the cost of preparing a regulatory proposal without sacrificing accuracy". The checking and validation of top-down forecasts is discussed further in Section 4.3 below.

Regardless of the forecasting methodology adopted for a given driver of expenditure, during the normal course of business Powerlink's actual capital expenditure is determined by its robust governance processes, underpinned by detailed bottom-up analysis that is required to support any final investment approval. While some stakeholders have considered this an argument in support of using bottom-up forecasting for all capital expenditure, Nuttall Consulting noted:[3]

> "D(etailed) E(ngineering) A(nalysis) (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. … 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. … 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."

As there is a continuum of investment needs and Powerlink has already approved capital expenditure extending into the next regulatory period this means that the overall capital expenditure forecast will need to combine elements of both bottom-up and top-down forecasting methodologies. The approach adopted by Powerlink to this integration task is described in Section 2

[3] Powerlink Revenue Proposal, Appendix 5.04, p. 22.

2 Predictive Repex Modelling

Powerlink has adopted the AER's Repex Model as the basis for the predictive modelling of network reinvestment needs. This model uses statistical techniques and asset specific information to forecast the level of reinvestment required. The data needed to populate the model is reflective of the data already provided to the AER through the annual Economic Benchmarking and Category Analysis Regulatory Information Notices (RINs) responses. Some adjustments to the RIN data were necessary to ensure the model provideed a realistic forecast of the reinvestment needs for the specific circumstances of Powerlink's network. These required data adjustments are described in the remaining sub-sections of where appropriate.

2.1 Relationship to RIN data

At the outset, it is important to recognise that Powerlink's level of asset capitalisation has implications for both how data is reported through the annual RIN process, and how the same data should be prepared for use in the Repex Model. Powerlink generally defines assets at a higher level of aggregation than the reporting categories for the RIN and those used for the Repex Model.

The most significant changes made relate to substation switchgear where Powerlink's assets are defined at the switchbay level, including all circuit breakers, instrument transformers, isolators and earth switches. For the Repex Model the switchgear category has been broken down into separate categories for circuit breakers, isolators and earth switches, voltage transformers and current transformers. This required transformation of any annual RIN data that had been reported at the switchbay level into the corresponding lower levels of equipment.

A description of Powerlink's units of plant for asset capitalisation purposes and relationship to the asset categories in the RIN data is set out in Table 2.

Table 2: Powerlink units of plant

Powerlink asset	Unit of plant - description	Corresponding RIN data items
Overhead transmission line	Built section – includes all structures, foundations, insulators, conductors and earth wires and associated hardware that were initially constructed to a common design under a single contract. A built section may comprise either a single or double circuit between two substations or a portion of the length between substations.	Transmission towers, Transmission tower support structures, conductors, OPGW
Underground cable	Built section – includes all cables, joints, and associated hardware that were installed to a common design under a single contract. An underground cable built section will always be associated with a single circuit.	Underground cable
Substation switchgear	Switchbay – includes the circuit breaker together with all associated CTs, VTs, isolators, earth switches, surge arrestors including structure and foundations required to switch a power system element to the busbar of a substation. It includes bus coupler bays.	Circuit breakers, CTs, VTs, Isolator /earth switches
Substation site infrastructure	Site infrastructure – includes site establishment such as road, fences, drainage and earthing, AC and DC supplies, including backup supplies.	Substation site infrastructure
Transformer	Power transformer – includes the main transformer, tapchanger, HV and LV bushings but excludes switchgear, protection and control equipment. Includes SVC main transformers.	Substation power transformer
Capacitor/Reactor	Independently controlled capacitor bank – includes inrush reactors and balance CTs but excludes switchgear, protection and control equipment. Independently controlled reactor – includes bushings but excludes switchgear, protection and control equipment.	Substation reactive plant
SVC	Static VAr Compensator – includes thyristor controlled reactor, thyristor switched capacitor and harmonic filter but excludes the thyristor valves themselves and the main transformer	Substation reactive plant
SVC thyristor valves	SVC thyristor valves – includes the valve cooling system.	Substation reactive plant
Substation buildings	Substation buildings – includes control buildings, communications buildings and workshop buildings.	Substation building
Substation secondary systems	Secondary systems bay – includes all protection and control equipment associated with the corresponding primary plant switchbay. Protection and control equipment not directly associated with a switchbay, such as bus protection, is part of a separate non-bay asset. Secondary systems bay – the metering unit associated with a switchbay.	Secondary systems asset (Powerlink defined) Metering asset (Powerlink defined)
Communication system	Communications link – microwave radio links, power line carrier (PLC) systems, multiplexors (MUX), fibre optic drivers.	Communications network assets

2.2 Calibration approach

The AER has published a Replacement Expenditure Model Handbook that sets out how the Repex Model can be used to develop a forecast of replacement capital expenditure. The handbook describes one use of the model as providing a benchmark forecast against which a TNSP's forecast can be compared. The key to the forecasting process is the calibration of the model. The handbook describes a calibration methodology based upon a single snapshot of the current age profile of the fleet of assets, together with recent history of actual replacement quantities. The basic steps of this methodology are, for each asset category:

1. Get the actual historical replacement volumes over the most recent duration that reflects the regulatory period;
2. Calculate the average annual replacement volume over this historical period;
3. Adjust the mean replacement life until the forecast volume of replaced assets in the first year of the forecast period equals the average actual volume calculated above;

4. Determine the annual percentage increase in the forecast volumes calculated by the model; and
5. Re-adjust the asset life to ensure the replacement volumes in the first year of the forecast period reflect this growth.

This calibration methodology implicitly assumes that the drivers for the recent actual replacement volumes are encapsulated in the current asset age profile. Powerlink considers that a better methodology is to break this down into two separate models:

- A calibration model that starts with an asset age profile as it was at the start of the period of actual replacement volumes; and
- A forecasting model that takes the mean replacement lives determined from the calibration model and applies them to the current asset age profile to derive the forecast.

The calibration model would then apply just the first three steps above with the mean replacement lives adjusted so that the calibration model generates average replacement volumes over the calibration period equal to the average replacement volumes that actually occurred. These mean replacement lives can then be applied to the forecast model based on the current asset age profile to derive a forecast that is calibrated to both the drivers of the historical replacement volumes and the current state of those drivers expressed through the current age profile.

The details of the calibration approach adopted by Powerlink are set out in sections 2.2.1 to 2.2.8 below.

2.2.1 Replacement statistics

In applying the Repex Model an important consideration is what probability distribution should be applied to simulate the reinvestment needs of the various asset categories. In all cases Powerlink has adopted a normal distribution and assumed that the standard deviation of the distribution is the square root of the mean life. This is consistent with the approach laid out in the AER's Repex Model Handbook. It is also consistent with Powerlink's asset management framework whereby asset condition and risk are the key drivers for replacement.

Powerlink considered the use of the Weibull distribution as an alternative to the normal distribution but concluded that it was not appropriate for several reasons.

Weibull distributions are often used for modelling end-of-life effects when actual failures have occurred within a population of assets. As noted above, Powerlink defines its assets at a relatively high level. Replacement of individual equipment items within an asset following failure, for example an individual CT or protection relay, is not treated as capital expenditure.

As a result, Powerlink's reinvestment capital expenditure is directed towards managing asset related risks prior to failure at the lowest long-run cost and not the replacement of assets or equipment that have failed in service. The distribution of expenditure for a given asset type around its mean replacement life is more appropriately described by the normal distribution. In addition, Nuttall Consulting noted:[4]

> "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 assumptions 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."

Powerlink considers it is reasonable and appropriate to adopt the AER's standard assumptions of a normal distribution with the standard deviation of the distribution set to the square root of the mean life.

2.2.2 Historical age profile

As described above, the starting point for Powerlink's calibration of the Repex model is an historical asset age profile. Powerlink has selected 30 June 2010 as the appropriate date for the historical asset age profile. This date allows the most recent five years of actual replacement data to be used to calibrate the model.

Nuttall Consulting observation

Powerlink was originally intending to adopt 30 June 2009 as the date for the historical asset age profile as that date reflects the fact that the earliest year for Category Analysis RIN data is 2008/09. This date would have allowed for the use of a longer historical data series of replacement volumes in the calibration model. Nuttall Consulting noted the AER's preference for a five year period for repex model calibration. Nuttall Consulting was also concerned that there could be a bias in regulatory incentives over a regulatory period and that any bias could be removed by adopting a five year calibration period[5].

Powerlink response

Powerlink has now adopted the most recent five years as the calibration period. Powerlink considers the shorter calibration period will better reflect prudent reinvestment decisions that have been made in the current environment of subdued demand growth forecasts. This decision has also been based on the documented practice of the AER in the Repex Modelling Handbook, Nuttall Consulting's observation of uneven regulatory incentives across regulatory periods, and the fact that the AER's Capital Expenditure Sharing Scheme has not applied to Powerlink to date.

2.2.3 Historical replacement quantities

Powerlink has reported quantities of assets and equipment replaced for each year from 2008/09 as part of the Category Analysis RIN data. These reported quantities from 2010/11 to 2014/15 form the basis of the quantities for the Repex Model to be calibrated against. Due to the methodology adopted by Powerlink for the preparation of RIN data, some of these reported quantities have been adjusted for use in the Repex Model. Details of the required adjustments are set out in section 2.4 below.

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[4] Ibid, p. 29.
[5] Ibid, p. 33.

2.2.4 Corrosion zone modelling

Powerlink's transmission network extends over 1,700km from north of Cairns in Far North Queensland to the New South Wales border in the south. This network traverses a wide range of climatic conditions ranging from hot and humid coastal tropical rainforests to milder and drier inland plains. As a result the galvanised steel components of transmission towers deteriorate at varying rates that depend largely on their location. It is the rate of deterioration of the galvanizing that largely determines the expected life of these structures and hence the need for reinvestment. The operating voltage or the circuit configuration is not a determinant of the expected life of a transmission line asset.

For the purposes of calibrating the Repex Model Powerlink classified its transmission towers based on corrosion zones. A description of these corrosion zones and the approximate proportion of transmission towers within each zone are set out in Table 3 below.

Table 3: Description of corrosion zones

Corrosion zone(s)	Description	Proportion of towers within zone(s) - approximate
B	Very mild corrosion environment, such as semi-arid environment, with low humidity and rainfall, and some rural activity. Average Annual Rainfall 400 - 900mm.	12.5%
C	Mild corrosion environment, such as typical rural areas with moderate humidity and rainfall, and average rural activity. Average Annual Rainfall 900 - 1200mm.	75%
D, E, and F (DEF)	Moderate to very aggressive corrosion environment such as inland coastal regions with average annual rainfall > 1200mm, high salt coastal regions and/or proximity to heavy industry.	12.5%

Powerlink's approach to calibrating the expected replacement life for transmission towers was to calibrate the actual replacement volumes in each corrosion zone separately. As described in section 2.4.1 below the replacement volumes for transmission towers also include the number of structures where maintenance intervention has been required to address advanced corrosion on individual towers within a built section. Powerlink considers this approach is justified as the maintenance intervention is of the same type (replacement of corroded components) and addresses the same end-of-life mechanism (deterioration of the steel structure) as the replacement quantities reported in the Category Analysis RIN data which is limited to capital expenditure.

Nuttall Consulting observation

Powerlink's original approach to calibrating the expected replacement life for transmission towers was to calibrate the actual replacement volumes in corrosion zone DEF against the population and age profile of transmission towers in that same zone. This was done as Powerlink's actual historical volumes of transmission tower structures that have reached end-of-life and required reinvestment has to date been largely associated with corrosion zone DEF. From this calibrated mean life for transmission towers in corrosion zone DEF Powerlink was then applying offsets to derive mean lives for transmission towers in corrosion zones B and C. The offsets were developed from Powerlink's asset management system records of the currently expected end-of-life for each built section within each corrosion zone.

Nuttall Consulting expressed concern with this approach and that the resultant forecast for transmission towers in corrosion zones B and C was significantly higher than was implied by the relatively low volumes requiring refit or replacement to date. While Powerlink was concerned that low volumes of historical replacement might reduce the accuracy of estimating what the mean life is, Nuttall Consulting was equally as concerned that the large number of towers that had "survived" to date must suggest that the mean life is longer[6].

Powerlink response

Powerlink accepts the points made by Nuttall Consulting that the survivability of the existing population of towers in corrosion zones B and C means that their mean replacement lives are not as short as was being inferred from the offsets approach. As described above Powerlink has now adopted a calibration approach where each corrosion zone is calibrated independently. This is also consistent with the approach adopted by Nuttall Consulting when reviewing Powerlink's forecasting models.

2.2.5 Transmission line refit vs replacement

As noted in section 2.2.4 above, it is the rate of deterioration of the galvanizing on the steel components that largely determines the expected life of transmission towers. Other sub-components of transmission lines that are similarly affected include insulator strings and overhead earthwire where corrosion of steel places a limit on service life. In most instances Powerlink expects to be able to perform reinvestment works to extend the useful life of the transmission line asset by replacing corroded nuts and steel members and painting the tower with a new coating of a zinc based paint. Where insulator strings and earthwire are similarly corroded these will also be replaced. This life extension strategy relies on there being significant remaining life in other major sub-components of the transmission line asset such as concrete foundations and conductor.

In a number of instances Powerlink has in-ground steel foundations for transmission towers (grillage foundations), instead of more conventional concrete foundations. Grillage foundations were typically used in transmission line construction up to the early 1960's, prior to the development of methods to provide significant quantities of batched concrete in remote locations.

Grillage foundations, particularly the air/ground interface at the base of the tower leg, experience a similar life as the rest of the tower structure. As the foundation would typically need to be replaced coincident with other significant works such as bolt and member replacement Powerlink considers grillage foundation structures as being not suitable for life extension. In these cases the more prudent strategy, where there is a continuing need for the services provided by the transmission line, is to replace the transmission line asset.

To reflect Powerlink's asset management strategies the population of transmission towers in the asset age profile have also been segmented by foundation type. Transmission towers with grillage foundations have been modelled as being replaced at their end-of-life with a unit cost to reflect the full cost of replacement. The remaining transmission towers without grillage foundations (the majority of the overall tower population) have been modelled as a line refit, with a unit cost to reflect the typical scope of work for a line refit project.

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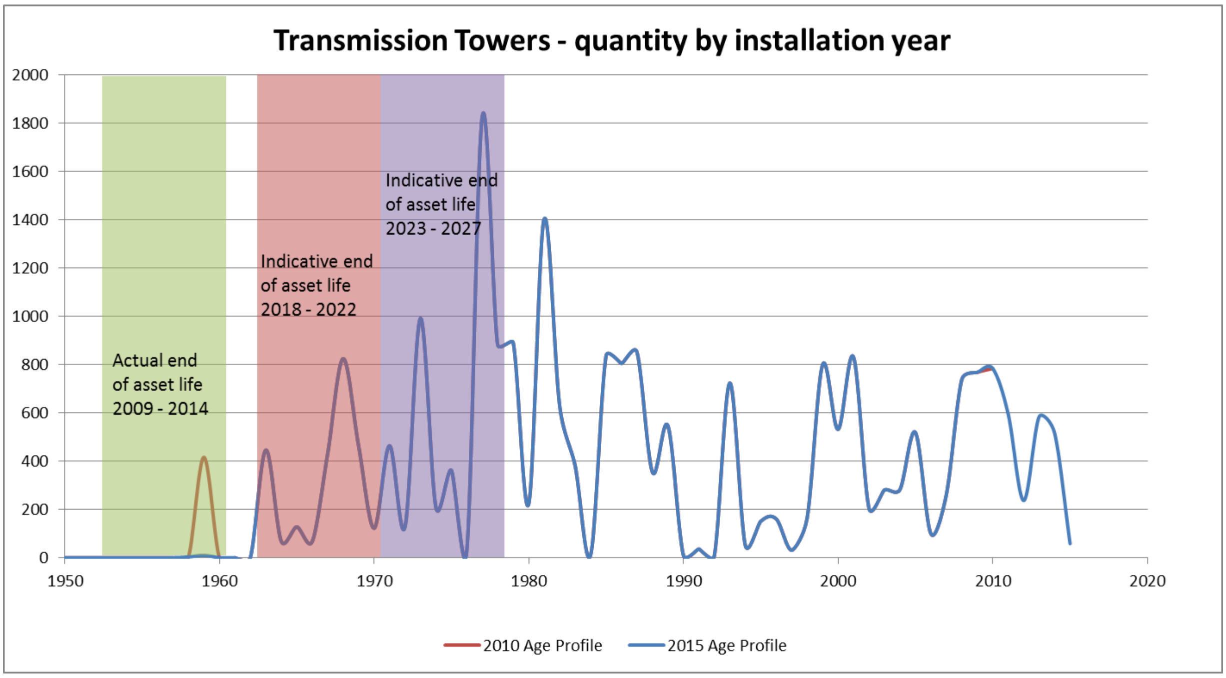
[6] Ibid, pp. 40-41.

Powerlink has three primary reinvestment strategies for transmission lines: replacement, refit (life extension), and decommissioning and disposal at end-of-life if there is no enduring need. The calibration methodology determines a mean life for the replacement strategy and Powerlink then models the refit strategy as an average advancement of 5 years earlier than the end-of-life replacement timing. The five year advancement is based on the following factors:

- As a significant part of tower painting is surface preparation, increased surface rust from delaying refit works to closer to end-of-life will require greater abrasive blasting to ensure the paint bonds to the existing surface. While this additional cost is allowed for in economic modelling, it increases the risk of the preparation being inadequate to allow the paint system to achieve the full life extension assumed in the economic modelling, which will potentially lead to additional cost over time.
- A large number of transmission towers are approaching the point where, without intervention, the ageing of these structures will lead to an exponential increase in the quantity of corroded components. This is due to the combined effect of an increase in the rate of corrosion as the galvanizing layer breaks down together with an increasing population of towers which are at the age when this acceleration of corrosion commences. Timely painting to restore the protective coating on steel components will prevent this exponential increase becoming potentially unmanageable.
- If the exponential increase in corroded components takes hold there is increased risk of not identifying all severely corroded items through normal maintenance activities which are currently based on routine or sample-based inspection.
- Delaying refit works until the end-of-life timing in all cases reduces flexibility in portfolio management and will result in a lumpy workload due to the large number of towers built during the 1960's and 1970's which are expected to reach their end-of-life at similar times. and
- Providing some flexibility in timing of refit works allows for the bundling of work packages across the transmission line asset (structure, earthwire, insulators) to achieve project execution synergies, minimise network outages and achieve a more effective life extension of the total built section asset.



Source: Powerlink data

While it may be possible to defer refit works until end-of-life for a single transmission line asset, it would not be prudent to attempt this across the entire fleet of more than 20,000 structures. The NPV costs of line refit and replacement are the same, within the accuracy of estimates, for refits up to 10 years prior to end-of-life. That is, the benefit of deferring refit timing to be closer to end-of-life timing is offset by the extra cost of remediating additional structure deterioration that occurs as a result of the deferral.

As there is no clear economic benefit from deferring refit works from when the justifiable need becomes apparent, and there are significant risks across the fleet of transmission towers from deferral, Powerlink considers that an average advancement for refit works of five years provides the most reasonable and efficient long-run outcome for electricity consumers.

2.2.6 Assets to be retired without replacement

Throughout the development of the transmission network since the 1960's, demand for electricity has increased year on year. The average annual rate of growth in maximum demand has generally been above 3% per annum and sometimes as high as 7% per annum. In such an environment it was almost always a planning assumption that the existing network would continue to be required and that the network would only ever be expanded in order to meet the increasing demand. Opportunities for consolidation or shrinking of the network were rarely evident.

In recent years this situation has changed markedly. Powerlink now forecasts the underlying demand for electricity transmission services to remain largely flat. Powerlink has responded to this new paradigm by viewing every reinvestment decision as an opportunity to consolidate the network. Powerlink's asset management planning process has identified a number of network assets that could be retired from service at their end-of-life and not replaced, while the required levels of supply reliability and network security continue to be met. The most significant assets identified for retirement are transmission lines assets. A summary of the number of transmission towers identified for future retirement is set out in Table 4 below.

Table 4 Transmission tower modelled future retirement quantities

Corrosion zone	Voltage	Single/double circuit	Number of towers
B	<=132kV	Single	602
		Double	38
	>=275kV	Single	0
		Double	0
C	<=132kV	Single	369
		Double	472
	>=275kV	Single	1052
		Double	51
DEF	<=132kV	Single	22
		Double	112
	>=275kV	Single	6
		Double	1
Total			**2725**

As Powerlink does not intend to spend any capital reinvesting in these identified assets, they have been removed from the asset age profile. It is important to note that removing these assets from the age profile does not mean they will all be retired within the 2018-22 regulatory period. They will be retired from service when they reach their respective end-of-life. The removal of these assets from the age profile is necessary to ensure that the Repex Model cannot forecast any future capital expenditure in relation to these assets. Where Powerlink does decommission and remove transmission lines from service this cost will be an operating expense.

2.2.7 Asset transfers

Periodically, asset transfers occur between Powerlink and Energex and Ergon. There may also be a book transfer of assets already owned by Powerlink, from a non-prescribed category of transmission services into the regulated asset base[7]. Where asset transfers have occurred after the date of the 2010 asset age profile that is used for calibration, the RIN data was adjusted to account for the transfer. This is to ensure that the asset age profile used for calibration of the Repex Model is consistent with the asset age profile that is used for forecasting.

The most significant of these asset transfers has been the transfer of the Surat Basin 132kV assets between Tarong and Columboola from Ergon Energy to Powerlink on 30 June 2012. Most of these assets date from the mid-1980's and can be expected to require some level of reinvestment within the next decade.

2.2.8 Modelling specific asset reinvestment strategies

Powerlink has made some data adjustments for the Repex Model to model linkages to specific asset reinvestment strategies that have been identified outside of the Repex Model. Examples of these linkages include:

[7] As part of Powerlink's 2013-17 revenue determination the AER agreed to Powerlink's proposal to transfer a portion of non-regulated assets providing connection services to Kogan Creek Power Station into the RAB, as part the lowest cost augmentation of the transmission network between South West Queensland and South East Queensland.

- Powerlink's Asset Management Plan proposes to replace existing sections of single circuit, grillage foundation 132kV lines between Callide A, Biloela and Moura with new double circuit construction as part of a longer-term network reconfiguration in the area – to model this the existing single circuit towers have been removed from the asset age profile and replaced with double circuit towers of the same vintage and foundation type. This has been offset by the removal from the age profile of other single circuit transmission lines in the area to model a longer-term network reconfiguration strategy which can be enabled by the double circuit replacement;
- Powerlink is not proposing to replace any substation reactive compensation equipment as part of the Revenue Proposal – all switchgear associated with reactive plant has been removed from the asset age profile;
- Transformer replacements were estimated on a bottom-up basis – where a transformer replacement project has identified a need to replace switchgear as part of the replacement project the original switchgear has been removed from the asset age profile; and
- Metering asset quantities were inferred from the quantity of secondary systems assets forecast from the Repex Model – the trigger for replacement of metering assets is a general secondary systems replacement at a substation site rather than an age or condition driver of the metering asset itself.

2.2.9 Modelling changes to incorporate stakeholder feedback

During the course of developing the capital expenditure forecasts for the 2018-22 regulatory period Powerlink consulted with and sought input from a range of stakeholders. In particular, Powerlink hosted two area plan forums, in July and October 2015, to seek stakeholder input into plans for managing emerging end-of-life issues for transmission lines in the Brisbane metropolitan area and the Central Queensland to Southern Queensland coastal circuits.

Transmission Network Forum (Brisbane area plans)

In this area plan forum stakeholder views were sought on the topics of network resilience, the strategic value of easements and the impact on different stakeholders of different reinvestment strategies. To facilitate discussion on these topics Powerlink presented a case study where Powerlink may be able to retire, without replacement, several existing transmission lines when they reach their respective end-of-life timings. The more transmission lines that are retired without reinvestment the greater the potential savings in transmission costs but this is offset by a lower threshold of demand growth that will then trigger the need for additional future investment to meet reliability of supply obligations.

The key themes of feedback provided by participants include:

Network resilience

- If trading off network resilience with cost savings, Powerlink should ensure the savings are material to the consumer as a portion of their electricity bill and that if reliability is reduced that the risks are adequately communicated to network users.
- With existing and forecast population growth Powerlink should be taking a longer term view when considering reductions to network resilience, as growth will continue in Brisbane. Powerlink should also be mindful of the forecasting uncertainty.

- Decisions that reduce network capability should be considered carefully due to the economic value of lost load in the greater Brisbane area.

Strategic value of easements

- Many participants expressed that Powerlink would lose the opportunity to use easements in the future if transmission lines were decommissioned or that the future costs and risks of obtaining access to these easements for construction would be prohibitive.
- Given the uncertainty in future demand growth, participants suggested that Powerlink apply low cost innovative maintenance techniques to keep the transmission lines going for a reasonable period.
- In addition to economic aspects Powerlink should also consider social aspects such as visual amenity, consideration of ongoing value of easements as greenspace in built up areas and impacts on property values.

Stakeholder impacts

- It is important to ensure that if Powerlink seeks to maintain ageing assets on easements that public safety risks are well managed.
- The concept of electrically disconnecting transmission lines is generally not supported. The assets cannot be effectively monitored and if they are genuinely not required to provide a transmission service then it is probably best that they are physically removed.
- Powerlink should continue to monitor and investigate changes observed in consumer behaviour to build confidence in the implications on demand and energy forecasts.
- Powerlink should ensure broad consultation on these types of decisions with stakeholders including Energex, relevant regional councils and other bodies, considering aspects such as reliability of supply and future land use.

Based on this feedback Powerlink has concluded that stakeholders do not want Powerlink to remove transmission lines from service at their end-of-life and lose access to valuable easement rights. However Powerlink will look for lower cost ways to retain these transmission lines safe and serviceable without significant capital reinvestment. For those specific transmission lines identified as potential retirements Powerlink has removed them from the asset age profile in the Repex Model so that there will be no forecast capital expenditure associated with reinvestment in these transmission lines in the 2018-22 regulatory period.

Area Plan Forum (Central Queensland to Southern Queensland coastal circuits)

In this area plan forum stakeholder views were sought in relation to a number of criteria that may be applied when considering reinvestment strategies for the original 275kV transmission lines between Central Queensland and Southern Queensland (CQ-SQ). A case study was presented that considered two broad reinvestment themes as examples for participants to consider when assessing their relative priorities of different criteria. The two reinvestment themes were a single circuit line refit and a double circuit line rebuild. The existing CQ-SQ 275kV coastal circuits comprise three single lines from Gladstone to Gin Gin to Woolooga (near Gympie) and two single circuit lines from Woolooga to South Pine (north Brisbane). Both themes represent a reduction in transmission line infrastructure from the existing network.

The criteria that were considered included lowest long-run cost of investment, asset condition, the importance of transfer capability and the future operability of the network. Additional criteria identified by participants included minimising the risk of asset stranding under demand forecast uncertainty and the ability to modify an option if conditions change[8].

The key findings from the participant discussions were:

- Participants did not think that historical network investments have resulted in positive market outcomes for consumers. As a result, consumers are unlikely to be comfortable in selecting an option that may offer additional future benefits at a higher upfront cost.
- Participants were keen to see Powerlink adopt an incremental approach to investment such that future alternative options were not eliminated.
- Some participants were comfortable with a larger load at risk.
- Participants felt that while reducing the cost of future investment was important, it should not come at the detriment of network reliability.

Powerlink has not yet made a firm decision on a specific reinvestment strategy, but nevertheless expects that some initial reinvestment will be required during the 2018-22 regulatory period. Based on the feedback from stakeholders Powerlink has removed one the three circuits between Gladstone and Woolooga from the asset age profile so that there will be no forecast capital expenditure associated with reinvestment in these transmission lines. The remaining two sets of single circuit lines have been modelled as line refits in the Repex Model. As there is a spread of ages between these two sets of remaining circuits, the modelling reflects the incremental approach to forecast reinvestment that stakeholders were keen to see.

2.3 Age profile

As described in Section 2.2 above, there were several areas where Powerlink has made a number of adjustments to the original RIN data. These changes have been made so that the Repex Model better reflects Powerlink's actual asset management practices and is able to produce a credible and reasonable forecast. This section provides more details of specific adjustments that Powerlink has implemented to the asset age profiles.

For each type of asset, the 2010 asset age profile starts with a new extract from Powerlink's corporate enterprise resource planning database, SAP, while the 2015 asset age profile starts with the reported RIN data for that year.

2.3.1 Transmission line structures

The starting point was all transmission towers that were recorded in SAP as at 30 June 2010. The following adjustments were then made:

- Spare structures that are not in service in the field were removed from the population – these structures are normally recovered from the field following other works such as line deviations or realignments and are in a condition suitable for re-use;

8 This is the option value benefit under the Regulatory Investment Test for Transmission (RIT-T).

- Structures that were removed from Powerlink's asset base after 30 June 2010 without reinvestment were removed from the population – these structures were either removed without replacement, removed as part of an augmentation project or transferred to a DNSP. As the removal of these structures had no influence on the actual replacement quantities after 2010 they were removed from the population for calibration purposes;
- Structures acquired by Powerlink through a transfer of assets after 2010 were added to the population based on their original year of construction – if Powerlink has acquired pre-2010 constructed assets that may require reinvestment in the future period Powerlink considers those assets should form part of the population as at 2010 for the purposes of calibrating the Repex Model;
- A small number of structures (18) had been refit prior to 2010. The nominal life extension achieved by this refit work is 20 years – in other words they now appear to be 20 years younger. To model this refit work these structures were removed from the age profile from their original construction year of 1964, time shifted by 20 years and placed in the age profile in 1984; and
- Structures that have been identified as having no need for reinvestment in the future were removed from the population – as described in section 2.2.6 above Powerlink does not intend to spend any capital reinvesting in these structures so they were removed from the Repex Model.

The structures that remain in the 2010 asset age profile were then categorised by their assigned corrosion zone.

For the 2015 asset age profile the starting point was the RIN data provided to the AER. The same process for data adjustments that were made to the 2010 asset age profile was also made to the 2015 asset age profile. One additional data adjustment was made to the 2015 asset age profile.

As discussed in section 2.2.8 above Powerlink has removed the 127 single circuit 132kV structures of the Biloela to Moura line from the age profile in 1965 and replaced them with 127 double circuit 132kV structures in 1965. This ensures that the asset age profile used for forecasting reinvestment quantities is a population that Powerlink genuinely expects will require reinvestment of that type in the future.

2.3.2 Conductors

The phase conductors installed on Powerlink's transmission lines are exclusively aluminium, either all aluminium alloy (AAAC) or aluminium with a steel core (ACSR). Powerlink has no history of capital expenditure driven by the age / condition of conductors[9] and does not expect any with the next regulatory period. Powerlink has incurred some capital expenditure to replace short lengths of conductors in order to realign line entries to substations as part of substation replacement projects. Powerlink expects this driver for the replacement of conductor to remain in the future.

As this expenditure driver for conductors is not related to the age profile of the conductors Powerlink has not used the calibration or forecast models to develop a forecast for conductor reinvestment.

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[9] Significant conductor replacement has occurred as part of transmission line replacements, but this has been driven by the condition of tower structures, foundations, and other line hardware, and not by the condition of the conductor.

2.3.3 Substation switchgear

For substation switchgear significant adjustments were required to the asset age profile from the RIN data in order to be made appropriate for the Repex Model. As discussed in section 2.1 above Powerlink's unit of plant for asset capitalisation of substation switchgear is the switchbay, rather than the individual equipment within the switchbay such as circuit breakers or instrument transformers.

As described in Powerlink's Basis of Preparation for the Category Analysis RIN[10] Powerlink reported quantities in the asset age profile at the asset (switchbay) level rather than the quantities of equipment within each switchbay. Powerlink applied a hierarchy in the following order:

- GIS module;
- Air insulated circuit breaker;
- Air insulated isolators / earth switch;
- VT; and
- CT.

In the RIN data if a switchbay contains an air insulated circuit breaker, together with multiple isolators, VTs and CTs it is counted once as an air insulated circuit breaker bay.

Notwithstanding this, it is not necessary for all equipment in a switchbay to be replaced for that expenditure to be considered capital expenditure. Replacement of a substantial proportion of the equipment within the switchbay that results in an extension to the life of the asset or a substantially improved asset is sufficient for a new asset to be established and the expenditure capitalised.

For this reason Powerlink considers it more reasonable to use the Repex Model to forecast quantities of equipment replaced within switchbays, based on historical quantities of equipment that have been replaced as capital expenditure. The historical replacement quantities reported in the RIN are already for individual equipment items, not whole switchbays.

The result of this is that Powerlink has had to redevelop the substation switchgear part of the asset age profile based on the year that individual equipment items were installed, instead of the year that the switchbay asset was first commissioned as reported in the RIN. This was done by taking the same basic data from SAP as was used for the asset age profile in the RIN data and building the age profile at the equipment level, rather than the switchbay level.

The starting point for validating the redeveloped age profile against the RIN data is the air insulated circuit breakers, as this was the top level of the hierarchy established in the RIN data for air insulated switchgear. If each switchbay asset has only one circuit breaker then there should be alignment between the RIN data and the Repex Model age profiles for circuit breakers.

Powerlink has found that the redeveloped age profile for the Repex Model has around 2% more circuit breakers than the RIN data age profile. The reason for this is that there are some switchbays with more than one circuit breaker:

[10] http://www.aer.gov.au/system/files/Powerlink%202013-14%20-%20Category%20Analysis%20RIN%20-%20Basis%20of%20Preparation%20D14%20149022.pdf, pp. 55-56.

- On some long 275kV feeders there is a shunt connected line reactor with a circuit breaker to switch the shunt reactor in addition to the circuit breaker associated with the switchbay – the RIN age profile would only count this as one circuit breaker switchbay but there are two circuit breakers within the bay; and
- On some 275/132kV or 275/110kV transformers the low voltage side has circuit breaker switching to more than one busbar – the RIN age profile would only count this as one circuit breaker switchbay but there are two circuit breakers within the bay.

The redeveloped substation switchgear age profile also includes busbar related equipment such as bus VTs and bus earthswitches that are not associated directly with switchbays but whose historical replacement quantities have been reported in the RIN. This busbar related equipment is not captured in the asset age profile RIN data.

By this process a base asset age profile has been redeveloped at the equipment level, instead of the switchbay level of the RIN data, for both 2010 and 2015. Following this, further adjustments have been made. Some adjustments were made for similar reasons as the adjustments to the transmission structures age profiles, while some others were unique to the switchgear category:

- Spare switchgear, in stores or kept at substation sites, was removed from the population;
- Switchgear that has been removed from Powerlink's asset base after 2010 without reinvestment was removed from the 2010 population;
- Switchgear acquired by Powerlink through a transfer of assets after 2010 was added to the 2010 population based on their original year of construction;
- Switchgear that has been identified as having no need for reinvestment in the future was removed from the population – this is associated with the decommissioning without replacement of the corresponding feeder;
- Switchgear whose replacement has been already forecast in the bottom-up estimates of transformer replacement was removed from the population; and
- Switchgear associated with reactive compensation plant was removed from the population.

For the 2015 age profile only, Powerlink has added in the number of CTs that are associated with dead tank circuit breakers[11]. This is so the forecasting model will generate a reasonable forecast for the number of CTs to be replaced. These CT units were not included in the 2010 age profile for the calibration model as they would only be replaced in conjunction with their host circuit breaker. The result of this approach to calibration is that the calibrated mean replacement life for CTs is not influenced by any replacement of CTs on dead tank circuit breakers which are driven by the condition of the circuit breaker, not the included CT. Nevertheless they should be included in the 2015 age profile for the forecast model as there will be a future need to replace these CTs.

Nuttall Consulting observation

Nuttall Consulting raised a concern regarding the way in which Powerlink was treating CTs associated with dead tank circuit breakers. Based on the data that Powerlink had available at the time Nuttall Consulting observed that:

[11] Dead tank circuit breakers incorporate CTs inherently in their design, in the bushings of the circuit breaker.

- The 2014 age profile had around 200 fewer CTs in total than the 2009[12] age profile;
- The 2014 age profile had around 800 fewer CTs installed at or before 2009 compared to the 2009 age profile which was a substantially bigger difference than the reported replacement quantity; and
- There was no change in the number of dead tank circuit breakers between 2009 and 2014.

All of the observations combined led Nuttall Consulting to conclude that dead tank circuit breakers have a significantly different life from the CTs.

Powerlink response

Powerlink has identified that the way in which information on CTs associated with dead tank circuit breakers is stored within SAP has changed over time. This meant that the data available at the time of the Nuttall Consulting review omitted the CTs on the more recently installed dead tank circuit breakers. This was the reason for the 'missing' CTs identified by Nuttall Consulting. Based on the most recent data the reduction in the number of older CTs is now more than matched by the number of more recent CTs, reflecting both the replacement of older CTs, but also installation of new CTs as part of Powerlink's network augmentation over the last five years.

From the calibration model Powerlink has not identified a significant difference in the mean replacement life of CTs versus circuit breakers. As the installed base of older dead tank circuit breakers is relatively small, around 3% of the total population of CBs, Powerlink considers there is little to be gained by pursuing a different form of modelling for dead tank circuit breakers and their associated CTs compared to the general population.

2.3.4 Secondary systems

As described in section 2.1 above, Powerlink's unit of plant for secondary systems assets is at the switchbay level. In addition, there is normally a non-bay secondary systems asset at each substation site.

For each of the 2010 and 2015 asset age profiles Powerlink made further adjustments for similar reasons as the adjustments to the substation switchgear age profiles, as follows:

- Secondary systems that have been identified as having no need for reinvestment in the future were removed from the population;
- SVC secondary systems have been removed from the population – these are highly specific control systems and Powerlink is not anticipating any capital expenditure on these items in the 2018-22 regulatory period.

The secondary systems age profiles were split between bay assets, non-bay assets and metering assets. A single weighted average unit rate for both bay and non-bay assets was used for forecasting expenditure on these secondary systems reinvestments. The forecast quantity of non-bay asset reinvestments was then used to derive a forecast of the quantity of metering assets to be replaced based on the relative populations of bay, non-bay and metering assets.

[12] At the time Nuttall Consulting was conducting the review Powerlink was using 2009 as the basis for the Calibration Model.

Nuttall Consulting observation

For substation secondary systems Nuttall Consulting observed anomalies between the calibration model and forecasting model. Nuttall Consulting postulated that this could be caused by Powerlink attempting to model a single replacement mechanism when there may be two different replacement mechanisms: one replacing the older population of assets with a longer mean life and the other replacing new assets with a shorter mean life[13].

Nuttall Consulting also queried Powerlink's use of the Repex Model for metering assets as it appeared to be an "artificial" use of the model[14].

Powerlink response

In analysing the asset age profile in the RIN data, Powerlink identified that a number of secondary systems assets had a recorded capitalisation data of 1 July 1996. This appears to be a default value set to the start of Powerlink's first full financial year as a corporate entity. Powerlink considers this data to be erroneous and for these assets has identified an alternative date based on the start-up date of the physical equipment recorded in SAP. Powerlink initially set this date to the oldest item of equipment associated with that secondary systems asset. This was the dataset analysed by Nuttall Consulting.

After considering the observations of Nuttall Consulting, in determining an appropriate start-up date Powerlink has now limited its consideration to the major protection and control equipment such as protection relays and Remote Terminal Units (RTUs). This approach now ignores ancillary equipment such as timing systems and transducers. This ancillary equipment may pre-date the main components of the secondary systems asset, but any need to replace the older equipment would not be a trigger for capital expenditure to replace the entire asset. The resultant age profile no longer appears to exhibit the characteristics of multiple replacement mechanisms that Nuttall Consulting observed in the original data. As a result Powerlink considers it is appropriate to model substation secondary systems assets using a single mean replacement life.

Powerlink has also clarified the forecasting of metering reinvestments. Previously the Repex Model was used by setting a mean replacement life to generate quantities that match the previously derived forecast. Powerlink now simply adopts the forecast of meter replacements derived from secondary systems asset replacements outside of the Repex model according to the following formula:

$$forecast\ meter\ replacements = forecast\ substation\ secondary\ systems\ replacements * \frac{total\ meters}{total\ substation\ secondary\ systems}$$

2.3.5 Telecommunications

Powerlink's telecommunications assets are such that individual financial assets provide a good match for equipment items to be modelled in the Repex Model. For this reason Powerlink has adopted the age profile of financial assets as the basis for the 2010 and 2015 asset age profiles.

[13] Ibid, pp. 47-48.
[14] Ibid, p. 48.

2.3.6 Site infrastructure and buildings

The reported RIN data has a single category for the site infrastructure asset category and a single category for the buildings category. The site infrastructure category included both substation sites and dedicated communications sites, however buildings only include substation buildings. Powerlink has recognised that there is a substantial difference in scale between a conventional substation site and a dedicated communications site. Powerlink has therefore segmented the reported RIN data to split both site infrastructure and site buildings between substation sites and communications sites.

For each of the 2010 and 2015 asset age profiles Powerlink has made the following adjustments:

- Added in dedicated communications buildings; and
- Removed amenities and workshop buildings where these have been separately identified – Powerlink does not expect any drivers to replace general amenities buildings as part of substation reinvestment activities.

2.3.7 Conclusions

Powerlink has made a number of adjustments to age profiles from the original RIN data. These changes allow the Repex Model to better reflect Powerlink's actual asset management practices and to produce a credible and reasonable forecast. The main areas where adjustments have been made are:

- Restating the substation equipment at the equipment level, as the original RIN data was expressed at the switchbay level;
- Removing equipment which Powerlink has identified can be retired from service in the future without needing replacement;
- Allowing for transfers into / out of Powerlink's regulated asset base over time;
- Splitting some RIN data types into sub-types; and
- Providing alternative start-up dates for a number of secondary systems assets based on the age of the key equipment within the asset.

Nuttall Consulting observation

Given the number of adjustments to RIN data necessary to adapt the data to the Repex Model, Nuttall Consulting suggested implementing some form of audit process to provide a level of assurance that the age profiles are accurate and fit for purpose[15].

Powerlink response

Powerlink has considered the Nuttall Consulting suggestion to implement some form of audit process. Powerlink agrees with the suggestion and engaged KPMG to provide an assurance statement that the age profile data used in the Repex Model is accurate.

[15] Ibid, p. 50.

2.4 Historical replacement quantities

The starting point for establishing the historical replacement quantities used in the Repex Model calibration is the Category Analysis RIN data reported to the AER. As noted in section 2.2.3 above Powerlink has identified some circumstances where the reported quantities should be adjusted in order to be appropriate for use in the Repex Model. These circumstances are discussed in more detail in sections 2.4.1 to 2.4.6 below.

2.4.1 Transmission line structures

In reviewing replacement quantity data for the Repex Model Powerlink identified two errors in the RIN data:

- In 2012/13, 42 structures had been reported as being replaced, when they were actually refit (life extended); and
- In 2010/11, four structures that had been refit were not reported.

Powerlink also reviewed all projects where transmission tower structures had been replaced and identified those structure replacements that were not driven primarily by the condition of the structures. Structure replacement not based on condition has normally associated with major substation replacement works where feeder entries to the substation have been realigned. As these replacement quantities were not driven by the age / condition of the structures they were removed from the historical replacement quantities. The quantities of structure replacements there were removed are summarised in Table 5:

Table 5 Structure replacements not based on tower condition

Voltage	Circuit configuration	Quantity	Corrosion zone	Year	Notes
110/132kV	Single Circuit	5	C	2013/14	Richlands Substation Replacement
110/132kV	Single Circuit	5	DEF	2013/14	Gladstone Substation Replacement
110/132kV	Double Circuit	6	DEF	2010/11	Cairns Substation Replacement
110/132kV	Double Circuit	12	C	2014/15	Collinsville Substation Replacement
275kV	Double Circuit	27	C	2010/11	Swanbank Substation Replacement
275kV	Double Circuit	21	DEF	2013/14	Gladstone Substation Replacement

Both the Gladstone and Swanbank substation replacement projects involved the relocation of a major transmission network switching node from an existing power station site to a new Powerlink owned site. In both cases the new site is remote from the old site and necessitated the physical realignment of a significant number of circuits. These two projects were the last for this design practice where the transmission substation was co-located with the power station. The other projects involved replacement either on the existing site or rebuilding immediately adjacent to the existing site. This required significantly less work to realign the circuit connections.

While Powerlink has removed all of the above structure replacements from the historical replacement quantities for input to the Repex Model calibration Powerlink considers there is still an ongoing need for some similar transmission line works as part of future substation reinvestments. As the Gladstone and Swanbank type of substation replacements are not expected in the future they have been discounted and the remaining structure replacement quantities considered as indicative of the quantity required to support future substation reinvestments. This gives an annual average of around five structures per annum which is included in the capital expenditure forecast. This is outside the Repex Model forecast which is only forecasting capital expenditure for transmission tower structures on the basis of condition drivers.

As described in section 2.2.5 above Powerlink has adopted a calibration approach for transmission towers that calibrates each corrosion zone separately. For corrosion zones B and C Powerlink has to date had very few instances of capital expenditure for replacement or refit of structures based on their condition. Steel lattice transmission towers are somewhat unique in the context of repex modelling in that the maintenance activities that address the earliest stages of their degradation towards ultimate end-of-life are the same activities that are performed under capital reinvestment when they are further along their degradation path – replacement of corroded components. For Powerlink, the difference is that addressing the corrosion on the first few structures in a built section asset is operating expenditure. It is only when a substantial proportion of the entire built section is requiring intervention that it is undertaken as a capital project. While it is the same type of intervention, for the same reasons, under both operating and capital expenditure, it is only the quantities addressed under capital expenditure that were captured in the annual RIN data as transmission tower refurbishment.

As the maintenance activities to address severely corroded components were fundamentally the same intervention as for capital expenditure for line refit works Powerlink considers the quantities managed under maintenance need to be included in the historical quantities for the calibration of the Repex Model. The reason for this is that the calibration is deriving the mean replacement life for transmission towers, based on their condition. These additional quantities in each of the corrosion zones in the calibration period were:

- Corrosion zone B +2
- Corrosion zone C +56
- Corrosion zone DEF +34

While it is appropriate that these additional quantities, based on maintenance work, were included for the purposes of deriving a mean replacement life, it is important to recognise that these quantities of interventions on structures will continue to be addressed under maintenance and not form part of the capital expenditure forecast. To ensure there was no double counting, the appropriate costs for this ongoing maintenance work were removed from the resulting Repex Model forecast.

2.4.2 Conductors

Powerlink is not using the Repex Model to forecast any conductor replacements for the following reasons:

- As described in section 2.2.5 above Powerlink is modelling the replacement of transmission lines where the existing structures have grillage foundations. In doing this, the unit rate for that asset category includes all costs to replace the transmission lines, including conductor costs. Costs are based on a typical span length for the relevant type of structure to be replaced (e.g. 132kV double circuit).
- As described in section 2.4.1 above Powerlink is forecasting transmission line realignment for substation reinvestment, including conductor costs, using the average of recent historical quantities.

2.4.3 Substation switchgear

In relation to substation switchgear Powerlink has identified an improved method of determining base replacement quantities, compared to the method used for the RIN data. The basis for the original RIN replacement quantities was to use procurement records to identify the quantity of each type of equipment purchased under each replacement project. The issue with using procurement records is that some equipment may be purchased under a project and ultimately held as spares or eventually used under a subsequent project.

Powerlink has now been able to utilise equipment records from SAP to more accurately identify quantities of equipment actually installed on an annual basis under capital replacement projects. This has also allowed for more accurate segmentation of the replacement quantities by voltage level.

Other adjustments made to the replacement quantities reported in the RIN data were:

- Removal of quantities associated with replacement volumes that are not expected to be relevant for future forecast quantities – examples include capacitor bank balance CTs and use of high burden VTs as replacement for substation AC supplies;
- Use of dead tank circuit breakers when both circuit breaker and CTs require replacement results in the quantity of CT replacements being understated as only the circuit breaker quantity has been reported in the RIN data – the quantity of CTs not previously incorporated in a dead tank circuit breaker, and replaced by CTs within the dead tank circuit breakers have been added to the replacement quantities; and
- Where the replacement of equipment was not completely condition driven, for example replacement for safety reasons due to excessive fault level, that replacement quantity has been removed from the quantities reported in the RIN data.

A summary of the overall adjustments made to the reported RIN quantities over the 2010/11 to 2014/15 period is set out in Table 6 below.

Table 6 Summary of adjustments to switchgear RIN replacement quantities (2010/11 – 2014/15)

	CBs	Isol/ ES	VTs	CTs
Original RIN replacement data	160	649	358	257
Adjustment – Procurement Records to Equipment Records	+2	-44	-20	13
Adjustment – Equipment types not being replaced in forecast	0	0	-12	-4
Adjustment – CTs replaced by dead tank CBs	0	0	0	+207
Adjustment – non condition drivers	-20	-87	-50	-90
Final replacement quantity for calibration	142	518	276	383

Source: Powerlink data

2.4.4 Secondary systems

The reported RIN data provided the total replacement quantities for all secondary systems assets under a single heading. For use in the Repex Model Powerlink has segmented the secondary systems assets into the following sub-categories:

- Bay secondary systems;
- Non-bay secondary systems;

- SVC secondary systems; and
- Metering assets.

Within each of these sub-categories Powerlink has identified the following adjustments to the replacement quantities:

- In two instances it appears that transformer secondary systems were counted as secondary systems bay assets – they are not a separate asset;
- At one site, a number of mixed assets (providing both prescribed and negotiated services) were double counted;
- At one site the replacement non-bay secondary systems were originally capitalised under a different project and not captured in the RIN data – the first project was categorised as Other instead of Replacement;
- For one SVC secondary systems replacement both the SVC secondary systems and the SVC thyristors were counted as separate SVC secondary systems assets; and
- In a number of instances the telecommunications assets were capitalised after the completion of the project and were not captured in the reported quantities in the RIN data.

The total of all of these adjustments over the 2010/11 to 2014/15 period is set out in Table 7 below.

Table 7 Summary of adjustments to secondary systems RIN replacement quantities (2010/11 to 2014/15)

	Secondary systems				
	Bay	Non-bay	SVC	Metering	Total
Original RIN replacement data	363				363
RIN data split up by secondary systems function	297	25	2	39	363
Total of quantity adjustments	-9	-1	-1	0	-11
Final replacement quantity for calibration	288	24	1	39	352

2.4.5 Telecommunications

Within the telecommunications category Powerlink has identified a number of instances where the telecommunications assets were capitalised after the completion of the project and so were not captured in the reported quantities in the RIN data. This adjustment results in an additional 87 telecommunications assets replaced in the calibration period.

2.4.6 Site infrastructure and buildings

The reported RIN data provided the total replacement quantities for substation buildings only, and provided these under a single heading. For use in the Repex Model Powerlink has segmented the substation buildings into four:

- Control buildings;
- SVC buildings;
- Workshop buildings; and
- Amenities buildings.

Powerlink has included only the control building quantities within the historical replacement quantities for use in the Repex Model and has added in communications buildings as a separate category of replacement quantity.

Powerlink has also segmented the site infrastructure category between substation site infrastructure and communications site infrastructure.

2.5 Forecast expenditure

2.5.1 Forecast quantities

Powerlink's Forecast Repex Model, when calibrated, produces a forecast of replacement quantities for each of the types of assets and equipment. The unit of plant for each of the asset and equipment types is set out in Table 8 below.

Table 8 Units of Repex Model quantity forecasts

Asset / Equipment	Units	Notes
Transmission Towers (Grillage)	Per tower	Transmission line replacement – includes conductor replacement and assumes a typical span length
Transmission Tower (non-Grillage)	Per tower	Transmission line refit – includes a proportion of earthwire replacement and assumes a typical span length
Circuit Breakers	Per 3-phase unit	
Isolator / Earth Switch	Per 3-phase unit	
VT	Per 1-phase unit	
CT	Per 1-phase unit	
Secondary Systems	Per unit	Includes both bay and non-bay assets in proportion to total population
Metering	Per unit	Assumes metering assets are replaced in the same ratio as the overall secondary system population
Telecommunications	Per unit	
Buildings	Per building	
Site Infrastructure	Per unit	

2.5.2 Unit rates

Appendix 7.01 of the Revenue Proposal sets out Powerlink's approach to developing unit rates to be applied to the forecast quantities produced by the Repex Model.

3 Trend modelling

3.1 Expenditure modelled using trend models

While the majority of non-load driven network capital expenditure is forecast using the Repex Model there is some expenditure that is forecast using trend based models. This includes:

- Reinvestment outside of the Repex Model – some reinvestment expenditure is not captured in the asset categories envisaged by the Repex Model. This typically involves smaller upgrades or enhancements to existing assets.
- Security / Compliance – as a provider of critical national infrastructure Powerlink has an obligation to maintain and enhance the physical and cyber security of the transmission network. This also includes expenditures to ensure compliance with amendments to various technical, safety or environmental legislation.
- Other – all other network expenditure, such as enhancements to communications systems and insurance spares.

Forecast expenditure from these trend based models constitutes around 6.5% of Powerlink's total capital expenditure forecast.

3.2 Modelling framework

The basis for using this form of model for forecasting capital expenditure is that there is a generally recurring level of expenditure in these categories that is necessary for the ongoing provision of prescribed transmission services. For example, there is an ongoing need for capital expenditure to sustain operational technologies between major reinvestments.

When reviewing this part of the modelling framework Nuttall Consulting concluded that[16]:

> "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."

Nuttall Consulting did identify some areas of concern and these are noted in the following sections, together with Powerlink's response.

3.2.1 Revealed historical expenditure

The starting point for each of the trend models is the actual historical capital expenditure in that expenditure category for each year. Expenditure from 2010/11 to 2014/15 has been used as the basis for trending consistent with the five year calibration period for the Repex Model.

[16] Ibid, p. 61.

3.2.2 Removal of non-recurrent/abnormal expenditure

Within each category of expenditure, analysis of individual projects has been undertaken to identify projects for which the historical expenditure should not form part of the base trend. Powerlink has adopted the following criteria and process to identify expenditure that should be removed from the historical expenditure base and what expenditure should be added back in to the resultant forecast after trending:

- A single project's cost is substantially greater than the other project costs in that category of expenditure, or:
- A single project is a one off project, whose investment driver is unlikely to be repeated in the foreseeable future.

A single project's cost is considered significantly greater that other project costs if the total cost of the project is greater than two standard deviations above the average of all projects in that category of expenditure. Powerlink considers that if a project is significantly more expensive than others in its peer group then it is not representative of a general trend of expenditure in that category. If the driver for that large expenditure is periodic then it should be more readily identifiable as a specific need in the future and the next project of that type can be added back into the future trend.

Projects whose investment driver is unlikely to be repeated include:

- Relocation of the disaster recovery site – Security and compliance category;
- Programs of work to upgrade the physical resilience and compliance of transmission towers – Security and compliance category;
- Establishment of a new telecommunications network platform technology – Other category; and
- Purchase of system spare transformers – Other category.

Nuttall Consulting observation

The programs of work to upgrade transmission tower resilience and compliance noted above were undertaken through a series of smaller projects. This ensured the scope of works for each segment of the program was limited and clearly delineated and ensured project governance, including budgetary control, was manageable. In the initial development of the forecasting models Powerlink had retained these separate projects in the historical base expenditure. Nuttall Consulting identified that these projects were in fact two programs of work that could be viewed as large one-off expenditures and removed from the base expenditure[17].

Powerlink response

Powerlink agrees with Nuttall Consulting and has now treated these smaller projects as two programs of work. As a result the expenditure on these projects has been removed from the historical trend.

3.2.3 Forecast base expenditure

Once the non-recurrent and abnormal expenditure in each category has been removed the resulting historical base expenditure is trended forward in time as the forecast base expenditure. Powerlink has used the annual average historical expenditure to generate this forecast.

[17] Ibid, pp. 59-60.

Nuttall Consulting observation

Where Powerlink had initially used a linear trend function to forecast the security / compliance category Nuttall Consulting considered the historical average may be more appropriate. Nuttall Consulting noted that if there is a continuing upward trend in expenditure it would be expected that the underlying mechanism driving that trend would be understandable and modellable[18].

Powerlink response

After considering the observations of Nuttall Consulting and the rationale behind those observations, Powerlink agrees that the forecast base expenditure across each of the three models should be based on the annual average historical expenditure. Powerlink has removed the use of a linear trend function from the security / compliance model.

3.2.4 Addition of non-recurrent/abnormal expenditure

Once a forecast base expenditure has been developed any new non-recurrent or abnormal expenditure has been added back on to the trend forecast. Powerlink has only applied this in the Other category to include the 2nd stage of deployment of a new wide area network capability to substations.

Nuttall Consulting observation

In reviewing the forecast step changes applied to the forecast Nuttall Consulting identified that a large project to implement accurate fault location facilities is added as a step change, but that earlier projects for similar facilities were not removed to produce the base. It could be argued that some part of the identified step change in expenditure is already reflected in the base forecast[19].

Powerlink response

Powerlink has reviewed its future program to deploy accurate fault location systems. Powerlink now considers it to be more reasonable to deliver future deployments of this technology within the envelope of the historical expenditure trend and has removed this particular step change from the forecast.

3.3 Forecast expenditure

Similar to the Repex Model Powerlink has interpreted the capital expenditure forecasts from these trend models as being the capital expenditure as-incurred. Powerlink's approach to forecasting capital expenditure as-commissioned is set out in Section 4.2 below.

[18] Ibid, pp. 60-61.
[19] Ibid, p. 61.

4 Developing the Hybrid Forecast

4.1 Integrating bottom-up and top-down forecasts

Even for categories of expenditure where Powerlink is forecasting future capital expenditure using top-down models, there is already capital expenditure in those categories that has been approved on a bottom-up basis. The task then becomes how best to transition from forecast expenditure for approved projects developed on a bottom-up basis to forecast expenditure for unapproved works developed on a top-down basis.

The approach that Powerlink has adopted is set out in the steps below:

- The approved capital expenditure budget for the current year is adopted – this is almost entirely for approved projects but also includes some early expenditure on projects that are not yet fully approved, but are currently under development;
- Beyond the current financial year (2015/16) each category of expenditure where top-down forecasting is applied is considered in turn – Reinvestment, Security / Compliance and Other;
- Within each category the forecast capital expenditure for each asset class – such as transmission lines, substation primary plant or secondary systems – is separately identified for both approved projects and the top-down forecast;
- For each year for each asset class in each expenditure category Powerlink has used the greater of approved project expenditure and the top-down forecast as the forecast capital expenditure for that year; and
- Where expenditure in an asset class for approved projects is greater than the top-down forecast in any year, an amount equal to the difference has been removed from the top-down forecast in adjacent years. This has been done so that the total forecast overall matches the top-down forecast.

The basis for this approach is that approved projects represent the most accurate forecast of future capital expenditure in any given year, as well as the most accurate forecast of the asset class breakdown.

4.2 Expenditure as-incurred vs as-commissioned

The Post Tax Revenue Model (PTRM) requires capital expenditure forecasts to be provided on both an as-incurred and an as-commissioned basis. In bottom-up forecasting the as-incurred capital expenditure is modelled using a project S-curve to spread the total expenditure over a multi-year period leading up to the project commissioning. All assets in the project are then assumed to be capitalised on the project commissioning date. As the top-down forecasting models are not based on specific projects a different approach is needed to model the two different treatments of capital expenditure.

As the capital expenditure forecasts produced by the top-down models are not limited to integer quantities of equipment Powerlink has interpreted these forecasts as being the capital expenditure as-incurred. Powerlink expects most of the capital works program in the forthcoming regulatory period to involve the progressive reinvestment in existing assets on existing sites. In most instances new assets will be commissioned and capitalised towards the end of a project, consistent with Powerlink's current practice.

Powerlink's typical network project implementation incurs the majority of expenditure over a two year period following project approval. For this reason Powerlink is assuming that capital expenditure as-commissioned is generally recognised in the year following the capital expenditure as-incurred.

Powerlink has developed the Repex Model so that only integer quantities of asset or equipment reinvestment are recognised for commissioning in each year of the forecast. Any remainder from the integer quantity is then carried forward into the subsequent year and the process repeated. The one exception to this methodology is transmission lines.

As Powerlink's unit of plant for transmission line assets is defined as a built section, reinvestment in the asset is not completed until all structures in the built section have been refit or replaced. Powerlink has modelled as-commissioned capital expenditure by accumulating the various forecast quantities for the different structure types from the Repex Model until there is sufficient number to match the oldest built section of that type. Once sufficient quantity has been accumulated the total capital expenditure for that quantity is recognised as the as-commissioned capital expenditure for that asset.

This accumulation process has been modelled outside of the Repex Model using a stand-alone application written in Python, with the results reported back within the main Repex Model.

4.3 Checking and validation

Powerlink has undertaken a number of checks and validations for the capital expenditure forecasts produced from these top-down models to ensure they are reasonable. These checks have included:

- Comparing the calibrated replacement lives against industry norms;
- Comparing Repex Model unit costs against indicative bottom-up project estimates;
- Comparing Repex Model quantities against Asset Management Plans.

4.3.1 Replacement life statistics

The calibrated replacement lives for the categories of assets and equipment used in the Repex Model are set out in Table 9 below.

Table 9 Calibrated replacement lives

Primary category	Sub-category	Replacement life (years)	Standard deviation (years)
Transmission towers (all voltages and circuit configurations)	Corrosion zone DEF	40.3	6.3
	Corrosion zone C	57.9	7.6
	Corrosion zone B	71.4	8.5
Substation switchbay equipment (all voltages)	Circuit breakers	34.2	5.8
	Isolators/earth switches	39.8	6.3
	Voltage transformers	34.6	5.9
	Current transformers	33.2	5.8
SCADA, Network control and protection	Secondary systems bay and non-bay (excl Metering)	20.2	4.5
	Communications	10.7	3.3
Building and infrastructure	Substation buildings	34.3	5.9
	Communications buildings	42.3	6.5
	Site infrastructure	50.6	7.1

Powerlink's standard replacement life for transmission towers in the high corrosion zones (DEF) is noticeably shorter than for other TNSPs. However this reflects the more extreme environment that these structures are exposed to. The standard lives for transmission towers in corrosion zones C and B are not dissimilar to the standard lives reported by other TNSPs.

For other categories of equipment the calibrated replacement lives appear to be comparable to the expected lives reported by other TNSPs in their RIN responses. Where Powerlink has calibrated replacement lives at the shorter end of the expected range, such as for substation switchbay equipment, this is for equipment that is installed outdoors. This equipment operates in harsh tropical and sub-tropical environments with high UV exposure and high humidity that will accelerate the ageing of components. Overall Powerlink considers the calibrated replacement lives to be reasonable.

For Repex Modelling purposes Powerlink has assumed a normal distribution for all categories of assets and equipment. Powerlink considers this to be reasonable as transmission assets are overwhelmingly replaced or retired prior to failing in-service. Alternative distributions, such as the Weibull distribution, are appropriate where there is a history of actual failures.

4.3.2 Comparison with bottom-up project estimates

Powerlink received significant stakeholder feedback in response to its proposal to adopt more top-down forecasting techniques in preparing capital expenditure forecasts. Based on this feedback Powerlink committed to providing additional bottom-up information to support the top-down forecasts. One use of this information is to compare the unit costs used in the Repex Model against the unit costs that can be inferred from a bottom-up project estimate. Powerlink has done this for several transmission lines and substation projects. For transmission lines the comparison is made using an inferred cost/structure from the bottom-up project estimate and comparing this to the appropriate unit cost in the Repex Model. For substations the Repex Model unit costs have been used to build up an equivalent project cost based on the quantities of equipment within the project scope and this is compared to the bottom-up project estimate.

It is important to note that individual project estimates were based on a specific scope of work while the Repex Model unit costs represent the cost for a typical scope of work across a large population. As such, it is expected that there will be material variability in unit costs at the level of individual projects, but that the overall average cost across a large portfolio of work will be comparable.

The results of these comparisons are set out in Table 10 and Table 11 below.

Table 10 Line projects comparison

Project	Project name	Tower type	Type	Unit cost - project estimate ($k)	Unit cost - Repex Model ($k)	Ratio
CP.01648	Swanbank-Redbank Plains-West Darra 110kV life extn	132 D/C	Refit	194.3	158.4	82%
CP.02304	Collinsville/Strathmore to Clare Line Refit	132 D/C	Refit	141.6	158.4	112%
CP.01647	Bioela - Moura 132kV T/L Replacement	132 D/C	Rebuild	306.2	287.2	94%
CP.01649	Callide - Biloela 132kV T/L Replacement	132 D/C	Rebuild	410.4	287.2	70%
CP.02415	Greenbank - Mudgeeraba 275kV T/L Life Extension (BS1019)	275 S/C	Refit	187.8	224.1	119%
CP.02532	Bergins Hill-Goodna-Belmont 275kV Line Life Extn	275 D/C	Refit	203	270.7	133%
Overall tower weighted average						105%

Table 11 Substation projects comparison

Project	Project name	Total cost of estimate $k*	Total Cost – Repex Model rates $k	Ratio
CP.01666	Dysart Substation Primary Plant Replacement Rebuild	9,954	10,843	109%
CP.02350	Bouldercombe Primary Plant Replacement	22,443	23,340	104%
CP.02340	H015 Lilyvale Primary Plant Replacement	7,328	5,027	69%
CP.01710	Gin Gin Substation Rebuild	22,116	22,025	100%
CP.02355	Ashgrove West Substation Rebuild	11,390	8,223	72%
CP.02617	Kamerunga Substation Rebuild	18,695	18,090	97%
	Overall Average	91,926	87,550	95%

* Excludes costs associated with rearranging transmission line entries. These costs are allowed for separately as part of the reinvestment expenditure forecasts.

4.3.3 Comparison with asset management plan

Powerlink's Asset Management Plan has identified a number of asset condition related risk factors that are forecast to drive asset reinvestment over the next decade. A comparison of the quantities of major asset and equipment reinvestment identified in the Asset Management Plan in the next regulatory period against the quantities forecast from the Repex Model is set out in Table 12 below.

Table 12 Comparison of key asset quantities

Asset category	Asset Management Plan quantity	Repex Model quantity
Transmission towers (rebuild)	185	37
Transmission towers (refit)	1246	918
Substation switchbay equipment (all equipment)	1017	981
Secondary system (bay and non-bay)	271	260

4.4 Overall assessment

Based on the checking and validation described in sections 4.3.1 to 4.3.3 above Powerlink considers the overall capital expenditure forecasts resulting from the various forecasting models to be reasonable. While there is some variability on individual items across the different checking sources Powerlink does not consider that there is evidence of a systemic upward bias in the forecasts that have been produced.