2023-27
POWERLINK QUEENSLAND REVENUE PROPOSAL

Appendix 5.04 – PUBLIC

Non-Load Driven Network Capex Forecasting Methodology

Contents

1. Introduction

As described in our Expenditure Forecasting Methodology (refer to Appendix 5.03), we have adopted a Hybrid+ approach to developing our capital expenditure forecasts for the 2023-27 regulatory period. The Hybrid+ approach has built on the experience, input and feedback gained during our previous revenue determination process and we have improved this approach for the 2023-27 regulatory period. For the non-load driven categories of network capital expenditure, Replacement, System Services, Security/Compliance and Other, we have adopted a mix of both bottom-up and top-down forecasting methods. This document sets out the basis on which we first established the boundary for our bottom-up forecasts and then describes the methodologies, data and models we have used to develop top-down forecasts of capital expenditure for a number of different elements of non-load driven expenditure.

1.1 Capital expenditure categories

The National Electricity Rules (the Rules) require us to forecast capital expenditure with reference to well accepted categories of drivers of capital expenditure. We have largely retained the same categories of capital expenditure as for the current regulatory period, except that we have included a new category of System Services. The categories of expenditure and the forecasting methodologies to be applied to each category are set out in Table 1.

Table 1: Categories of capital expenditure

Capital expenditure category	Definition	Forecasting methodology
Network – Load driven		
Augmentations	Relates to augmentations defined under the Rules. 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 Distribution Network Service Providers (DNSP) or other TNSPs. Associated works are identified through joint planning with the relevant Network Service Provider (NSP).	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	Relates to reinvestment to meet the expected demand for prescribed transmission services. Expenditure is primarily undertaken due to end of asset life, asset obsolescence, and asset reliability or safety requirements. A range of options are considered for asset reinvestments including, removing assets without replacement, non-network alternatives, life extension to extend technical life or replacing assets with assets of the same or different type, configuration or capacity. Each option is considered in the context of future capacity needs accounting for forecast demand and the changing mix and location of generation.	Top-down and bottom-up
System Services	Investments to meet overall power system performance standards and support the secure operation of the power system. This includes the provision of system strength services and inertia services.	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 system enhancements, improvements to network switching functionality and insurance spares.	Top-down
Non-network		
Business Information Technology (IT)	Expenditure to maintain IT capability and replace or improve business system functionality where appropriate.	Bottom-up and top-down
Support the Business	Expenditure to replace or improve business requirements including, commercial buildings, motor vehicles and other tools and equipment.	Bottom-up and top-down

1.2 Boundary for bottom-up forecasting

Within the network non load-driven category of capital expenditure we have adopted a mix of bottom-up and top-down forecasting methodologies. In adopting a Hybrid+ forecasting methodology, we set ourselves a target to have at least 60% of the total capital expenditure forecast based on bottom-up project estimates and justification. We set this target following engagement with our Revenue Proposal Reference Group (RPRG), a sub-set of our Customer Panel.

The challenge with such a target was establishing selection criteria to deliver set a capital investments with an aggregate value exceeding 60% of the total capital expenditure forecast.

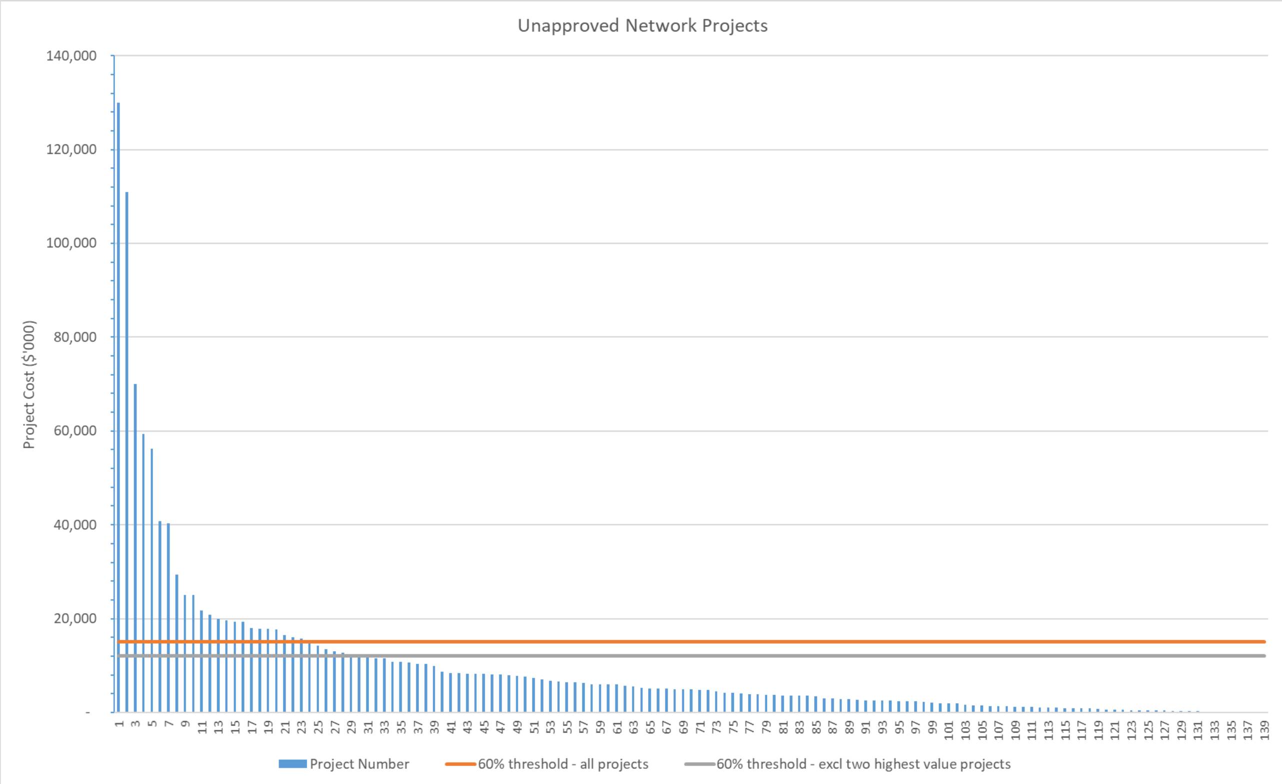
We approached this task using our Transmission Annual Planning Report (TAPR) as the key reference. Each year the TAPR includes information regarding future network augmentation and network reinvestment projects over a 10 year outlook period. As the 2020 TAPR was not published until October 2020 we analysed the information on future network reinvestment projects contained in the 2019 TAPR. We subsequently validated this against the information in the 2020 TAPR.

While the TAPR contains information on the estimated cost and anticipated completion date for reinvestment projects this information is necessarily preliminary in nature. It is not until the time of RIT-T analysis and project approval that final project scope, cost and timing is established. Notwithstanding this limitation, we consider the 2019 TAPR dataset to be suitable for this purpose.

To establish a cost threshold for projects to be included in the bottom-up forecast, we arranged the projects identified in the 2019 TAPR in descending order of total project cost. We then identified how far down the list we had to descend before the cumulative total of project costs exceed 60% of the total cost of all projects in the list. The cost of this last project would indicate the cost threshold for inclusion in the bottom-up forecast. This resulted in an indicative project cost threshold of $15m (nominal).

In analysing the 2019 TAPR dataset we noted that two future reinvestment projects had estimated costs significantly greater than other reinvestment projects, as a result of their size and complexity. To hedge against the possibility that either, or both, of these projects may not ultimately be included as part of the Revenue Proposal, we re-ran the analysis with these two highest value projects removed. This resulted in an indicative project cost threshold of $12m. This analysis is illustrated in Figure 1.

Figure 1: Determination of bottom-up project cost threshold



When the $12m indicative project cost threshold was applied, this resulted in 29 projects being included in our list of candidate bottom-up projects. This list of candidate projects was subsequently reduced when further condition assessment and planning analysis was undertaken. Additional bottom-up projects were also added to include proposed transformer reinvestment projects and projects to meet the need for system services.

Our approach to developing bottom-up forecasts is described in more detail in Section 2.

1.3 Overview of top-down forecasting models

We have developed two top-down forecasting methodologies to supplement the bottom-up forecasts:

1. Predictive Modelling – based on the Australian Energy Regulator's (AER's) Replacement Capital Expenditure (Repex) Model and which has been used to supplement the forecast capital expenditure for the major asset classes in the Reinvestment category[1].
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 top-down forecasting methodologies are described in more detail in Sections 3 and 4.

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. These processes are underpinned by detailed bottom-up analysis that is required to support any final investment approval. Much of our network capital expenditure is also subject to consultation through the Regulatory Investment test for Transmission (RIT-T) process.

As there is a continuum of investment needs and Powerlink has already approved capital expenditure extending into the next regulatory period, as well as unapproved bottom-up projects, this means that the overall capital expenditure forecast will need to combine elements of both

[1] These are overhead transmission lines (including grillage foundations), substation switchgear and secondary systems.

bottom-up and top-down forecasting methodologies. The approach adopted by Powerlink to this integration task is described in Section 5.

2. Bottom-up Justification

Our initial list of candidate bottom-up reinvestment projects was supplemented by transformer reinvestment projects identified within the 2019 TAPR as likely to require expenditure before the end of the 2023-27 regulatory period. We also included any other network non load-driven projects that represented one-off expenditure needs that would not be suitable to be captured in our top-down forecasting models such as our new category of investment driver, system services. This is consistent with our Expenditure Forecasting Methodology.

In addition to this subset of unapproved non load-driven projects, any projects that are already approved are included as part of the bottom-up forecast. As approved projects they have already been subject to our normal project governance processes, including business case approval by the relevant financial delegate.

For the remaining unapproved projects we have compiled a suite of supporting information (project packs) to support the inclusion of the project within the Revenue Proposal.

We have provided a separate Guide to Network Capital Expenditure Project Packs as a supporting document to help stakeholders understand the purpose of each document type and the information contained therein. A project pack typically consists of the following documents:

Project Pack summary

The Project Pack Summary provides an overview of the proposed investment based on excerpts of the detailed documents that follow. The summary identifies the asset, condition and network drivers for investment, potential options, associated risk monetisation, proposed timing and estimated cost for the investment.

Condition Assessment report

The purpose of this document is to assess the asset condition based on the asset inspection methodology. The Condition Assessment (CA) defines the need, and expected future timing for asset intervention where business as usual activities (e.g. routine inspections and corrective maintenance) no longer enable the network asset to meet prescribed service levels due to the deterioration of asset condition or obsolescence of the asset type.

Planning Statement

The Planning Statement defines the investment need and network risk of non-investment in the asset. Where an asset is identified as reaching its end-of-life, this document conceptually identifies both network and non-network options that enable the required level of transmission service to continue to be met (regardless of the asset deployed). This document also identifies levels of unserved energy at risk, and any non-compliances this would incur, if the asset is removed or fails in service.

Risk Cost Assessment

The purpose of this document is to quantify the base case risk cost profile for the asset, providing a monetised value for safety, network, financial and environmental risks posed by the condition or obsolescence of the asset, should it remain in service.

Project Scope Report

The Project Scope Report document defines the high level scope of proposed options required to achieve the project need and objective/s derived from the Planning Statement.

Project Estimate

The Project Estimate is a financial estimate of the labour, materials, equipment and subcontracts required to achieve the project scope option/s. Project estimates are developed using a first principles approach, where the estimate is calculated based upon the specific resources and quantities required to complete the defined scope of works.

3. Predictive Repex Modelling

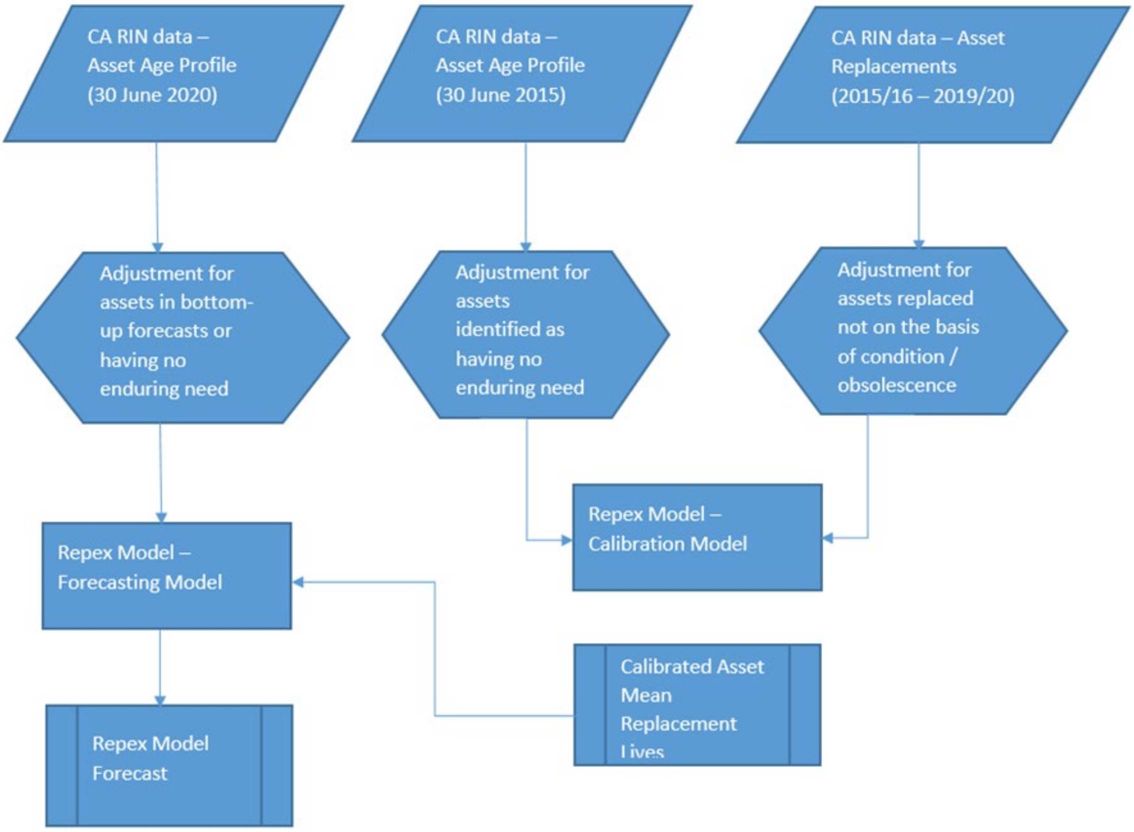
Once a suite a bottom-up project estimates has been established, our Hybrid+ forecasting methodology makes use of top-down forecasting techniques to provide the balance of the forecast capital expenditure. We have again adopted the AER's Repex Model as the basis for the predictive modelling of network reinvestments. The Repex Model uses statistical techniques and asset specific information to forecast the level of reinvestment needed.

Our approach to the use of the Repex Model is broadly in line with the modelling approach we adopted in our 2018-22 Revenue Proposal[2].

3.1 Repex Modelling Process

The high-level process for applying the Repex Model in our Hybrid+ forecasting methodology is shown in Figure 2.

Figure 2: Repex modelling process



[2] 2018-22 Revenue Proposal, Appendix 5.05 Non-Load Driven Network Capital Expenditure Forecasting Methodology, Powerlink Queensland, January 2016

3.2 Use of Regulatory Information Notice (RIN) data

Our starting point for the data used in the Repex Model is the data we have previously submitted to the AER through the annual RIN process. 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 from the RIN data 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: Description of asset categories

Powerlink asset [1]	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

(1) Not all asset types are represented in the Repex Model. Our Repex Model is limited to overhead transmission lines, substation switchgear and substation secondary systems.

3.3 Calibration of the Repex Model

Our approach to the calibration of the Repex Model is to start with the most recent five years of actual asset replacement data (i.e. 2015/16 to 2019/20) and our asset age profile at the start of that five year period (i.e. as at 30 June 2015). We then adjust the mean replacement life for each asset type individually until the forecast quantity of asset replacements produced by the Repex Model over the five year period equals the actual replacements undertaken during the same five year period.

The calibrated mean replacement lives are compared to the mean replacement lives arrived at by the AER as part of our previous Final Decision[3]. Where the newly calibrated mean replacement lives are shorter than those previously determined we adopt the longer life unless there are sound asset management reasons to retain the shorter life, such as changes in technology. Generally we adopt the longer of the mean replacement lives from our previous Final Decision and the updated calibration.

Further details of the specifics of our approach to calibration of the Repex Model are set out in Sections 3.3.1 to 3.3.7.

3.3.1 Previous Final Decision

In our 2018-22 Revenue Proposal we adopted the Repex Model as the primary method for developing our capital expenditure forecasts. In its Final Decision the AER published a set of asset mean replacement lives it accepted as being those that a prudent operator would require for replacement of those asset types[4].

Since those Final Decision mean replacement lives were published, we have made one material change in our asset management approach which will affect these values. For overhead transmission lines we previously used a certain level of steel tower corrosion as the trigger to commence reinvestment works, on the assumption it normally takes a number of years for capital projects to progress to completion. As our asset management systems and practices have continued to mature we have now adjusted this trigger level to be a forecast greater level of corrosion at the time of project completion.

The effect of this change has been to extend the mean replacement lives for transmission towers by between 1.5 and 4 years, from the previous AER Final Decision Values. The previous Final Decision asset mean replacement lives, including any adjustments for changes in asset management practices, are summarised in Table 3.

[3] For overhead transmission lines these have be extended by between 1.5 and 4 years as a result of changes to our asset management practices within the current regulatory period.

[4] Final Decision Powerlink transmission determination 2017-22, Attachment 6 – Capital expenditure, p.6-19, Australian Energy Regulator, April 2017.

Table 3: Changes to mean replacement lives due to asset management practices

Primary asset category	Asset sub-category	Final Decision mean replacement life	Adjustment to mean replacement life	Updated mean replacement life
Overhead transmission lines	Corrosion zone DEF	45.8	+1.5	47.3
	Corrosion zone C	61.1	+4	65.1
	Corrosion zone B	78.2	+3	81.2
Substation switchgear	Circuit breakers	35.2		35.2
	Isolators / earth switches	40.6		40.6
	Voltage transformers	35.1		35.1
	Current transformers	34.2		34.2
Secondary systems and telecommunications	Secondary systems (bay and non-bay)	20.6		20.6
	Telecommunications	10.7		10.7
Buildings and infrastructure	Substation buildings	34.3		34.3
	Communications buildings	42.3		42.3
	Site infrastructure	50.6		50.6

3.3.2 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 we have 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 our asset management framework whereby asset condition and risk are the key drivers for replacement.

Our reinvestment capital expenditure is directed towards managing asset related risks prior to their in-service failure, 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 most appropriately described by the normal distribution.

3.3.3 Historical replacement quantities

The starting point for establishing the historical replacement quantities used in the Repex Model calibration is the Category Analysis (CA) RIN data reported to the AER. We have 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 below.

Transmission towers

The CA RIN data reports the numbers of transmission towers that have been replaced or life extended, regardless of the reason for the work. We 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 is normally associated with substation replacement works where feeder entries to the substation have been realigned. As these replacement quantities are not driven by the age / condition of the structures we have removed from the historical replacement quantities. The quantities of structure replacements there have been removed are summarised in Table 4.

Table 4: Transmission tower reinvestments not due to asset condition

Voltage	Circuit configuration	Quantity	Corrosion zone	Year	Notes
66kV	Double circuit	17	B	2019/20	Tarong 66kV Cable Replacement
110/132kV	Single Circuit	2	B	2017/18	Moura Substation Replacement
110/132kV	Single Circuit	3	B	2018/19	Nebo Transformer Replacement
275kV	Double Circuit	5	C	2015/16	Swanbank Substation Replacement
275kV	Single Circuit	9	C	2015/16	Swanbank Substation Replacement

In addition to removing some structures from the replacement quantities we have also included additional structures. These are structures where reinvestment projects have commenced but the project has not yet fully completed and been reported in the annual CA RIN data. These additional structure quantities have been determined based on the proportion of the total project budget that was spent up to 30 June 2020 and are summarised in Table 5.

Table 5: Transmission tower reinvestments not yet reported in CA RINs

Voltage	Circuit configuration	Quantity completed	Corrosion zone	Total number of structures	Notes
110/132kV	Double circuit	184	C	199	Collinsville – Proserpine Inland Section T/L Life Extension
110/132kV	Double circuit	4	B	63	Alligator Creek – Eton T/L Life Extension
110/132kV	Double circuit	23	C		
110/132kV	Double circuit	23	DEF		
110/132kV	Double circuit	4	B	39	Egans Hill – Rockhampton T/L Life Extension
110/132kV	Double circuit	14	C		
110/132kV	Double circuit	3	C	16	West Darra – Sumner T/L Life Extension
110/132kV	Double circuit	3	C	22	Rocklea – Sumner T/L Life Extension
110/132kV	Double circuit	5	B	33	South Pine – Upper Kedron T/L Life Extension
110/132kV	Double circuit	1	C		
110/132kV	Single circuit	18	C	177	Townsville South – Clare South T/L Life Extension
275kV	Single Circuit	27	B	205	Woolooga – Palmwoods T/L Life Extension
275kV	Single Circuit	106	C		
275kV	Single Circuit	56	DEF		
275kV	Single Circuit	1	C	27	Calliope River 275kV Tower Refit
275kV	Single Circuit	18	DEF		

A summary of the adjustments made to the quantity of transmission towers used in the Repex Model calibration is in Table 6.

Table 6: Transmission tower quantities for Repex Model calibration

	Zone B	Zone C	Zone DEF
Original RIN replacement data	35	58	81
Adjustment – towers replaced other than based on condition	-35	-1	-20
Adjustment – towers refit but not yet reported	+72	+353	+97
Final replacement quantity for calibration	**72**	**410**	**158**

Substation switchgear

Prior to the current regulatory period we undertook several major substation reinvestment projects which involved rebuilding all, or a substantial part, of the substation on a new / adjoining site. As a result, some assets at the substation were replaced without there being a condition-based driver. This approach was justified in these circumstances as being the prudent and efficient solution meet the majority of asset condition needs, as well as accommodating other power system drivers at the time such as forecast increases in demand and fault levels.

From late in the 2013-17 regulatory period, and throughout the 2018-22 regulatory period, our substation reinvestments have closely targeted only those assets that have been identified with condition-based drivers for reinvestment. From our review of projects undertaken during this period we consider that all asset replacements have been driven primarily by the aging of the assets and that no adjustments to the historical replacement quantities is needed for the calibration of the Repex Model.

Similar to the transmission towers we have identified a number of instances where reinvestment projects in substation switchgear occur over a number of years. As a result some switchgear that is replaced early in the project does not get reported in the CA RIN data until some years later when the entire project is completed. We have identified where switchgear has already been replaced under reinvestment projects but not yet reported in the CA RIN data. Table 7 provides a summary of the adjustments to the CA RIN data to account for this.

Table 7: Substation switchgear reinvestments not yet reported in CA RINs

	CBs	Isol/ES	VTs	CTs
Original RIN replacement data	28	91	69	24
Adjustment – equipment replaced but not yet reported	+23	+61	+50	+150
Final replacement quantity for calibration	**51**	**152**	**119**	**174**

Substation secondary systems

Our reinvestment in substation secondary systems to date has been related to older installations that pre-date our standard designs. These sites have also been progressively expanded up to the late 2000's to meet demand growth resulting in a mix of generations of equipment. In many instances these older installations have exhibited deteriorated wiring, and presented safety risks to operational personnel from exposed wiring terminal and confined spaces. These factors have led us to invest in the replacement of full protection and control panels, including wiring, often in new demountable buildings. As a result some of the newer secondary systems assets at these substations have been replaced without there being an age-based driver, either asset condition or obsolescence.

We reviewed all projects in the 2018-22 regulatory period where secondary systems assets have been (or are being) replaced and identified those asset replacements that are not driven primarily by the asset condition or obsolescence. From this review we have identified that approximately 6% of secondary systems assets are replaced as part of the efficient bundling of work, with the remaining 94% being due to the aging of the assets.

The reported CA RIN data provides the total replacement quantities for all secondary systems assets under a single heading. For the Repex Model we have segmented the secondary systems assets into the following sub-categories:

- bay secondary systems;
- non-bay secondary systems;
- SVC secondary systems; and
- metering assets.

Similar to substation switchgear we have identified a number of instances where reinvestment projects in substation secondary systems occur over a number of years. As a result some secondary systems assets that are replaced early in the project do not get reported in the CA RIN data until some years later when the entire project is completed. We have identified where secondary systems assets have already been replaced under reinvestment projects but not yet reported in the CA RIN data. Table 8 provides a summary of the adjustments to the CA RIN data to account for this.

Table 8: Substation secondary systems reinvestments not yet reported in CA RINs

	Secondary systems				
	Bay	Non-bay	SVC	Metering	Total
Original RIN replacement data	210				210
RIN data split up by secondary systems function	174	13	0	23	210
Adjustment – equipment replaced but not yet reported	+46	+6	0	+11	+63
Final replacement quantity for calibration	**220**	**19**	**0**	**34**	**273**

3.3.4 Corrosion zone modelling

Our 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. As our asset management systems, and the data that supports them, have continued to mature we have continually refined this classification. As a result a number of structures that were previously classified as falling with zone C have been reclassified into zone B. A description of these corrosion zones and the approximate proportion of our existing population of transmission towers within each zone are set out in Table 9.

Table 9: Description of corrosion zones

Corrosion zone(s)	Description	Proportion of tower population 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.	35%
C	Mild corrosion environment, such as typical rural areas with moderate humidity and rainfall, and average rural activity. Average Annual Rainfall 900 -1200mm.	54%
D, E, and F (DEF)	Moderate to very aggressive corrosion environment such as coastal regions with average annual rainfall > 1200mm, high salt coastal regions and/or proximity to heavy industry.	11%

3.3.5 Assets to be retired without replacement

Throughout the development of the transmission network from the 1960's to the late 2000'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 the last decade this situation has changed markedly and forecasts of the underlying demand for electricity transmission services remain largely flat. We have responded to this new shift by viewing every reinvestment decision as an opportunity to consolidate the network. Our asset management planning process has identified a number of network assets that can 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.

As part of the calibration of the Repex Model we remove assets from the 2015 age profile where they were identified at that time as being able to be retired in the future without replacement. This ensures the calibration reflects the state of our asset management planning during the period covered by the calibration. In practice this means we adopt the asset age profile used for the forecasting model in our previous Revenue Proposal.

3.3.6 Grillage foundations

In a number of instances we have 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.

The nature of grillage foundations is such that metal just below the surface may be in serviceable condition, while corrosion can be present at depths of greater than 1m. Our remaining significant population of structures with grillage foundations is in the Central West area where the above ground steel work is considered to be in corrosion zone B (very mild). In this situation the grillage foundations are expected to reach their end of life well before the main body of the tower.

On other transmission lines with grillage foundations we have successfully adopted micro-piling to extend the life of the foundations and our asset management strategy is to adopt the same techniques to the remaining grillage foundations.

Given the inability to directly observe the condition of the grillage foundations, without invasive excavation which could exacerbate condition issues, we have adopted a mean replacement life for grillage foundations of 60 years. This is consistent with the age of reinvestment for other instances where it has been found necessary to micro-pile grillage foundations as part of transmission line life extension activities.

3.3.7 Calibration results

We have included our calibration Repex Model as supporting information with our Revenue Proposal. As noted at the outset of this discussion, we only adopt a calibrated mean replacement life that is shorter than the previous Final Decision value if it can be justified through a change in asset management approach during the current regulatory period.

A summary of the mean replacement lives adopted for our Repex Model forecasts is in Table 10.

Table 10: Calibrated mean replacement lives used for Repex Modelling

Primary asset category	Asset sub-category	2018 -22 Final Decision mean replacement life	Adjustment to mean replacement life	Updated Final Decision mean replacement life	Calibrated mean replacement life (2015-2020)	Mean replacement life used for Repex Model forecast
Overhead transmission lines	Grillage foundation repair	N/A		N/A	N/A	60.0(1)
Overhead transmission lines (refit)	Corrosion zone B	73.2	+3	76.2	62.8	76.2
	Corrosion zone C	56.1	+4	60.1	55.6	60.1
	Corrosion zone DEF	40.8	+1.5	42.3	43.6	45.1(2)
Substation switchgear	Circuit breakers	35.2		35.2	40.6	40.6
	Isolators / earth switches	40.6		40.6	48.9	48.9
	Voltage transformers	35.1		35.1	39.0	39.0
	Current transformers	34.2		34.2	39.9	39.9
Secondary systems and telecommunications	Secondary systems (bay and non-bay)	20.6		20.6	21.7	21.7
	Telecommunications	10.7		10.7	N/A	
Buildings and infrastructure	Substation buildings	34.3		34.3	N/A	
	Communications buildings	42.3		42.3	N/A	
	Site infrastructure	50.6		50.6	N/A	

(1) Refer Section 3.3.6.
(2) Calibrated mean replacement life adjusted by 1.5 years to reflect change in asset management practices within the current regulatory period.

3.4 Repex Model Forecasting

Having established a set of suitably calibrated mean replacement lives we have used the Repex Model to generate top-down forecasts that complement the bottom-up forecasts for a limited number of asset types. These are:

- grillage foundations;
- overhead transmission lines (limited use);
- substation switchgear; and
- secondary systems.

Each of these asset types are discussed in turn below.

3.4.1 Repex Model age profiles

Grillage foundations

We use the Repex Model to provide a forecast of the number of transmission tower structures with grillage foundations that will be life extended through micro-piling. The remaining population of grillage foundations in concentrated in the Central West area between Callide and Moura. These towers, which were built between 1963 and 1965, are located in corrosion zone B (very mild) and the above ground components are still in good condition.

Based on our experiences with grillage foundations in other locations we consider that a number of these foundations will require reinvestment to extend their life to match the expected service life of the above ground components. As noted in Section 3.3.6 we have adopted a mean replacement life of 60 years, consistent with what we have observed for other grillage foundations.

Overhead transmission lines

As described in Section 1.2 we determined a cost threshold for investment needs to be included in our bottom-up forecasts. The scale of transmission line reinvestment projects is such that practically all future asset reinvestment needs exceed this cost threshold. The result is that the bottom-up forecasts effectively cover the field in relation to transmission line reinvestments. For this reason we have not included the balance of our fleet of overhead transmission line assets within our Repex Model. The exception is those transmission line corridors that we originally targeted to be the subject of our proposed contingent reinvestment projects.

Based on feedback we received to our draft Revenue Proposal we are no longer proposing contingent reinvestment projects in our Revenue Proposal. Instead, we have included those transmission line assets that were to be the subject of contingent reinvestments in the Repex Model to provide a forecast for targeted life extension works.

As these are long transmission lines, typically around 150 – 300km long, the transmission towers experience a range of environmental conditions, even within the same corrosion zone. This results in a natural spread of rates of deterioration of the steel components, making a Repex Model top-down forecast appropriate for targeted life extension works.

Substation switchgear

For substation switchgear significant adjustments are required to the asset age profile from the RIN data in order to be made appropriate for the Repex Model. Our 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 our Basis of Preparation for our annual CA RIN[5] we report quantities in the asset age profile at the asset (switchbay) level rather than the quantities of equipment within each switchbay. We apply a hierarchy in the following order:

- GIS module;
- Air insulated circuit breaker;
- Air insulated isolators / earth switches;
- 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 we consider 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, with adjustments as noted in Section 3.3.3 are already for individual equipment items, not whole switchbays.

The result of this is that we have redeveloped 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.

We have 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:

- 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.
- 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 2015 for the calibration model, and 2020 for the forecasting model.

Based on feedback received from the AER on the use of the Repex Model we have also removed from the age profile those assets for which there is only a small population. The result is that the Repex Model for substation switchgear now only includes those assets for the 110/132kV and

[5] Category Analysis Regulatory Information Notice, Basis of Preparation 2019/20, pp47-48.

275kV voltage levels. We consider this further enhances the suitability of the Repex Model for use in out Hybrid+ forecasting methodology.

Secondary Systems

As described in Section 3.2, 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.

SVC secondary systems have been removed from the population – these are highly specific control systems and any reinvestment capital expenditure on these items in the 2023-27 regulatory period is part of the bottom-up forecast.

The secondary systems age profiles are split between bay assets, non-bay assets and metering assets. A single weighted average unit rate for both bay and non-bay assets is used for forecasting expenditure on these secondary systems reinvestments. The forecast quantity metering assets to be replaced is based on the relative quantities of metering assets other substation secondary systems assets according to the following formula:

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

For our 2018-22 Revenue Proposal this calculation resulted in 0.22 metering asset replacements for each secondary systems asset replacement, which was accepted by the AER. Updating the calculation for the 2020 asset population results in 0.24 metering asset replacements for each secondary systems asset replacement. We recognise this calculation is an abstraction used for the purposes of top-down forecasting so we have elected to retain the 0.22 factor previously accepted by the AER. This also results in a modest reduction in forecast capital expenditure compared to using the updated 0.24 factor[6].

Telecommunications

Our bottom-up capital expenditure forecasts include major reinvestments in our core telecommunications networks, based on the upcoming obsolescence and lack of manufacturer support of the digital equipment.

We have concluded that this level of reinvestment in the bottom-up forecasts is sufficient to manage the risks to service levels within the 2023-27 regulatory period and there is no requirement for supplementary Repex modelling.

Site infrastructure and buildings

We have previously included substation and telecommunications site infrastructure and building assets within our Repex Model. We received feedback from AER staff that given the non-homogenous nature of these asset types it is problematic to include them within the Repex Model.

We agree with this feedback and have removed these assets from our Repex Model. Instead, we have forecast these asset reinvestment needs using a separate trend model, as described in Section 4.

3.4.2 Assets not included in the Repex Model

Not all of the assets currently in service are included within the Repex Model. There are a number of reasons for excluding assets from the age profiles that are inputs to the Repex Model. These are:

- assets not suitable for Repex Modelling;
- assets with no enduring need; and
- assets included within bottom-up forecasts.

[6] A reduction in forecast capital expenditure of approximately $162,000 in the 2023-27 regulatory period

Assets not suitable for Repex Modelling

The Repex Model is best suited for forecasting reinvestment quantities for assets with large populations and that are largely homogenous in nature. The main asset types that are not suitable for inclusion in the Repex Model are:

- Power transformers – these are low volume and high cost items that have been forecast using a bottom-up approach.
- Static Var Compensators (SVCs) – these are low volume and high cost items that have been forecast using a bottom-up approach.
- Site infrastructure and buildings – these are low volume and non-homogenous in nature that have been forecast using a trend approach.

Assets with no enduring need

Our 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 but we apply the same process for other asset types within the Repex Model. We have identified a total of 1,468 transmission structures that could be retired in the future without reinvestment[7]. As we do not intend to spend any capital reinvesting in these identified assets, they are 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 2023-27 regulatory period, only that we do not anticipate the need to reinvest in these assets in the future.

Asset included within bottom-up forecasts

A key feature of our Hybrid+ forecasting methodology is that top-down forecasting techniques, including the Repex Model, complement the bottom-up forecasts which comprise nearly 80% of the forecast reinvestment capital expenditure.

Any assets that are included within the bottom-up forecasts are removed from the asset age profile that is an input to the Repex Model. This includes approved projects where assets are already committed to being replaced, and forecast bottom-up projects where the asset reinvestment is already included in the capital expenditure forecasts. Removing these assets ensures that any asset included within bottom-up forecasts cannot also contribute to the top-down forecasts.

As noted in Section 3.4.1 we have concluded that the bottom-up forecasts for reinvestment in overhead transmission lines and telecommunications systems has effectively covered the field and that a complementary top-down forecast for these assets is not warranted. The exception is that we have continued to use the Repex Model to forecast grillage foundation life extension works (approximately $8m) and to forecast targeted refit works on the overhead transmission lines that were previously the subject of our proposed contingent reinvestment projects (approximately $18m).

[7] This is less than the 2,519 structures identified in our 2018-22 Revenue Proposal as having no enduring need. The main change is that we now expected we will need retain the existing three 275kV circuits between Gladstone and Woolooga where we had previously identified the potential to reduce this to two circuits. In addition, some circuits previously identified as having no enduring need have now been decommissioned and removed.

3.4.3 Repex Model outputs

Our 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 11.

Table 11: Units of Repex Model quantity forecasts

Asset / Equipment	Units	Notes
Transmission Towers (Grillage)	Per tower	Includes micro-piling of all four foundations to extend the tower life.
Transmission Towers (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

The forecast quantities for each asset and equipment type are multiplied by their corresponding unit rate to arrive at the forecast capital expenditure. Appendix 7.03 Cost Estimating Methodology of the Revenue Proposal sets out our approach to developing unit rates to be applied to the forecast quantities produced by the Repex Model.

4. Trend Modelling

4.1 Expenditure modelled using trend models

While the majority of the top-down forecast for 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 in substation site infrastructure and buildings – some reinvestment expenditure is not captured in the asset categories envisaged by the Repex Model. This typically involves upgrades or enhancements to existing substation site infrastructure or building assets.
- Security / Compliance – as a provider of critical national infrastructure we have 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 – other minor network expenditure, such as enhancements to control centre facilities.

Forecast expenditure from these trend based models constitutes approximately 4% of our total capital expenditure forecast.

4.2 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 control centre capability between major reinvestments.

4.2.1 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 2019/20 has been used as the basis for trending. This is equivalent to two full regulatory periods and has been chosen so that any bias in regulatory incentives over a regulatory period is removed, while observing investment trends over a longer timespan than a single regulatory period.

4.2.2 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. We have 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. We consider 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 Swanbank Power Station switchyard to a new location – Reinvestment category;
- a major project to upgrade the physical security and resilience and compliance of a number of substation sites – Security and compliance category;
- establishment of a new telecommunications network platform technology – Other category; and
- purchase of system spare transformers – other category.

4.2.3 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. We have used the annual average historical expenditure to generate this forecast.

Similar to the Repex Model we have interpreted the capital expenditure forecasts from these trend models as being the capital expenditure as-incurred. Our approach to forecasting capital expenditure as-commissioned is set out in Section 5.2.

5. Developing the Hybrid+ Forecast

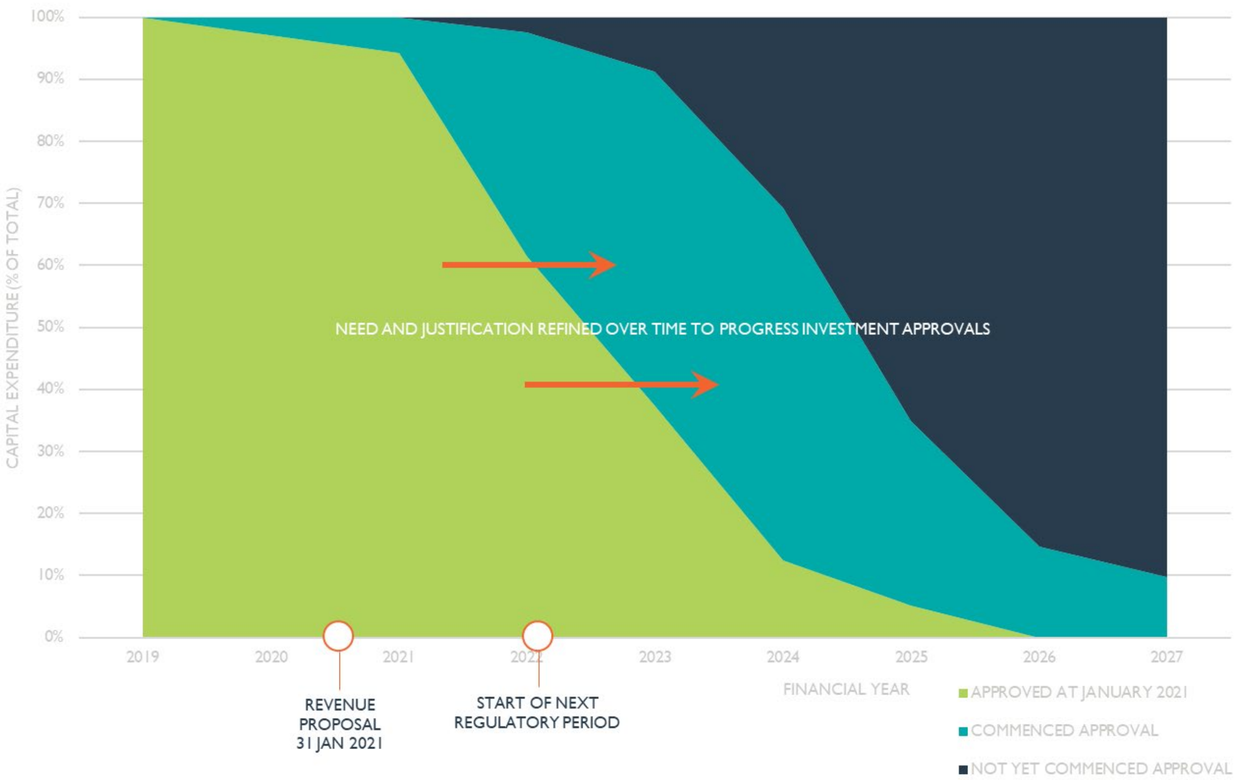
5.1 Integrating bottom-up and top-down forecasts

In our Hybrid+ methodology more than 70% of the forecast network non load-driven capital expenditure is from bottom-up project estimates. The top-down forecasting models, whether Repex Modelling or trend based models, are complementary and additive to the bottom-up forecasts.

Most of our forecast capital expenditure for the balance of the current regulatory period is made up of projects that are already fully approved and are now being implemented, or projects that are already progressing towards investment approval, such as undergoing a RIT-T consultation.

Figure 3 illustrates this normal progression and timing of investment approvals under our normal business practice and is further explained in Appendix 5.03 Expenditure Forecasting Methodology.

Figure 3: Capital expenditure forecasting phases



Given this profile of approved versus unapproved capital expenditure we have applied the top-down forecast capital expenditure to be in addition to any bottom-up forecast capital expenditure from 1 July 2022.

5.2 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 we have interpreted these forecasts as being the capital expenditure as-incurred. We expect most of the capital works program in the 2023-27 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 our current practice.

Our typical network project implementation incurs the majority of expenditure over a two year period following project approval. For this reason we are assuming that for top-down forecasts the capital expenditure as-commissioned is generally recognised in the year following the capital expenditure as-incurred.

We have 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 our 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. We have 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.