Program Business Need Identification

Power and Water Corporation

CONTROLLED DOCUMENT

NMFCR (PRD33437)

All Regions Condition and Failure Based Replacement Pooled Forecast

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Proposed:	Approved:
Stuart Eassie Manager Strategic Asset Engineering Power Networks Date: 15/2/2018	Michael Thomson Chief Executive Date: 23/02/2018

	Refer to email D2018/72353	Refer to email D2018/74133
Djuna Pollard Executive General Manager Power Networks Date: 15/2/2018	Finance Review Date: 06/02/2018	PMO QA Date: 16/02/2018

1 Project Summary

Program Name:	All Regions Condition and Failure Based Replacement Pooled Forecast		
Program No:	NMFCR / PRD33437	**SAP Ref:**	
Financial Year Commencement:	2019/20		
Business Unit:	Power Networks		
Project Owner (GM):	Djuna Pollard	**Phone No:**	898 58431
Contact Officer:	Stephen Vlahovic	**Phone No:**	892 45538
Date of Submission:	23 Feb 2018	**File Ref No:**	D2017/468452
Submission Number:	Sub	**Priority Score:**	
Primary Driver:	Renewal / Replacement	**Secondary Driver:**	Service Improvement
Program Classification:	Capital Program of Works		

2 Recommendation

2.1 MAJOR PROJECT >$1M OR PROGRAM

It is recommended that the Investment Review Committee (IRC) note the proposed five year distribution asset replacement program, aimed at addressing distribution assets that fail in service or become unserviceable due to poor condition, for an estimated budget of $36.05M, and approve the inclusion of this program into the SCI for this amount.

NOTE: Due to correction of an assumption in the model, the forecast expenditure requirement has increased from $35.7 million that was submitted in the Regulatory Proposal to $36.05 million, an increase of approximately $0.35 million.

The forecast for this program of work extends beyond the current SCI period. The first two years of this program aligns with the last two years of the 2017-18 SCI. This program will be included in the 2019-24 Regulatory Proposal to the Australian Energy Regulator (AER).

Note that individual projects within the program will be documented in Business Case Category Cs to be approved by the Executive General Manager Power Networks.

3 Description of Issues

3.1 Context

PWC has a relatively small network compared to other Distribution Network Service Providers (DNSP) in the National Electricity Market (NEM), but is located in a harsh environment which has strongly influenced the type of materials used on the network and how it is constructed. **Error! Reference source not found.** provides an overview of the volume of assets that are part of the Pooled Assets group.

Table 1 Asset population overview

Asset Group	As at November 2017	Average expected life
Overhead conductors	5,412 km	58
Pole top structures[1]	44,254 units	N/A
Underground cables	1,607 km	55
Service lines	55,074 units	35
Distribution transformers	4,630 units	45
Distribution switchgear	6,728 units	36
Connectors	Unknown	30
Surge arrestors	Unknown	45
Pillars	7,280 units	35

The age profile of assets in PWC's network is shown below in Figure 1. It is significantly influenced by Cyclone Tracey (1974) which destroyed a significant portion of the network and as a result there is a large peak in age profiles between 1974 and 1976 as the network was rebuilt. There was also a period of rapid expansion of the network that was driven by development of new suburbs between 1979 and 1985. These two events have created a large peak in most asset classes installed during those years.

[1] Based on one pole top structure per pole.

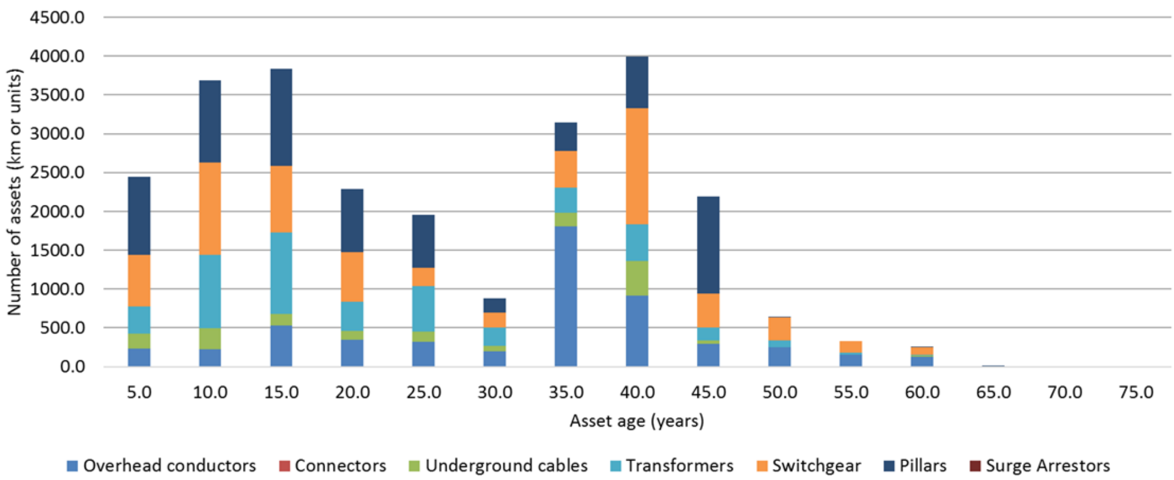

Figure 1: Distribution asset age profile

The age profile shows that there is a large peak in the assets that are currently between 35 and 45 years old as a result of Cyclone Tracey and the network expansion in the early 1980's. By the end of the next regulatory period these assets will be between 42 and 52 years old. As shown in Table 1, these assets have expected lives of between 35 and 58 years, indicating that a large volume of assets will be approaching or exceeding their expected lives and therefore the volume of assets requiring replacement is expected to increase.

The following sections describe the conditions that PWC operates in, the key asset replacement drivers, how the assets fail and common industry practice to managing these asset categories.

3.2 The Operating Environment

PWC's network is located in a harsh environment that includes climatic conditions, fauna and demand profiles that put pressure on distribution assets.

Climate

Approximately 80% of PWCs network is located in a tropical coastal environment that is prone to tropical storms, tropical lows and cyclones. High humidity and high annual rainfall have multiple negative impacts on the condition of distribution assets. The issues are a challenge that is unique to PWC compared to other distribution networks throughout Australia. Key environment factors, which are the highest in Australia and that contribute to deterioration include:

- The highest frequency of lightning: direct strikes or surges resulting from strikes damage assets or result in immediate failure
- Highest UV intensity: results in damage to polymer materials and is related to time in service and exposure to sunlight
- Highest rainfall/humidity:

    - increases water ingress into assets which accelerates deterioration, corrosion and results in early asset failure.
    - can make access to assets or undertaking maintenance difficult, and along with the high temperatures, reduces the productivity of field crews[2].
- Highest average temperatures: reduces the efficiency of cooling and limits the capacity of assets. Particularly high underground temperature reduces the current carrying capacity of cables, either reducing the power transfer or requiring larger cables to be installed (resulting in higher capex and repex).

Fauna

Throughout the Northern Territory there are issues with fauna damaging assets. In particular, very aggressive termites and boring insects eat through external sheaths of cables and cause failures. This is a common occurrence and can present issues with identifying the location of the fault and then replacement of the faulted section. Other common fauna issues include:

- Large populations of larger animals, such as snakes, bats and birds cause faults and damage on overhead conductors and insulators.
- Bats are significant issue during migration periods (often multiple periods each year) and commonly cause phase to phase and phase to earth faults as they hang between conductors or aggregate on crossarms.
- During the dry season, small snakes and frogs commonly enter cable termination compartments in switchgear for warmth causing flashovers that can often damage switchgear beyond economical repair.

Demand

Due to the heat and humidity, there is a very high penetration of air conditioners in use by industrial, commercial and residential customers. Air conditioners are typically used continually throughout the year which results in a high average demand per customer and a fairly flat demand profile. Figure 2 shows the demand profile for a day in NSW compared to the Northern Territory. The demand has been normalised (divided by the maximum) to show make the profiles comparable since the magnitude of the demand is significantly higher in NSW. The maximum difference between the maximum and minimum demand in the Northern Territory is 28% compared to 44% in NSW.

Constant utilisation of assets generates heat, reduces cooling cycles during the night, which leads to accelerated deterioration of insulation. Equipment ratings often consider the cycling of loads typical in other regions with closer to “typical” demand profiles experienced in the majority of the NEM.

[2] Labour Efficiency and Work Management in Hot Humid Climates, Thermal Hyperformance.

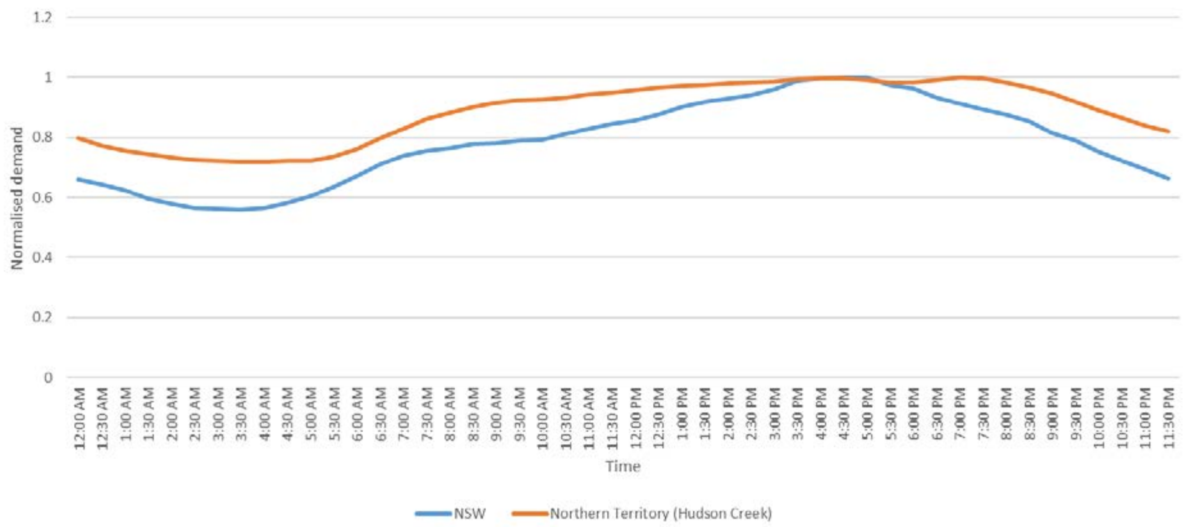

Figure 2 Comparison of average load profiles in NSW and Northern Territory

The cumulative impact of the operating conditions and age profile discussed above is an increased rate of asset deterioration, increased cost of managing the network and expected increasing trend in the volume of replacements required.

3.3 Asset replacement drivers

This BNI describes issues with distribution assets due to normal in service failures and unserviceability due to poor condition. The BNI targets the following asset types that are regarded as 'volumetric' meaning high volumes but low unit costs:

- Distribution transformers
- Distribution switches
- Overhead conductor
- Underground cables
- Connectors
- Pillars
- Surge arrestors
- Pole top structures
- Service lines

These distribution assets are found in publicly accessible locations as they are required for supplying electricity from zone substations at distribution voltages of 22kV through to connection to customer premises at voltages of 415V.

Over time the condition of these assets deteriorate and they eventually fail or become inoperable. Causes of asset deterioration include adverse environmental conditions, repeated operation of mechanical parts, and use above rated capacity. Events such as severe storms and lightning, animal contact, manufacturing defects and various other external influences can also cause premature failure of an asset or damage an asset in a way that is not economical to repair.

Asset failure or inoperability have two key consequences:

- **public health and safety risks:** these assets are located in publicly accessible areas and can result in arcing and fires, step and touch potential rises, and conductors falling to the ground. These failure modes pose hazards to public safety.
- **deterioration in network reliability:** there is generally no redundancy for these assets so a failure will result in an outage to customers.

PWC undertakes inspection and testing in accordance with the maintenance policy and associated strategies. The detailed tasks and frequency of inspection and testing to be undertaken for each asset type is generally based on analysis of observed asset failure modes, manufacturer's recommendations and benchmarking with other utilities through various industry forums. During testing and inspection, assets are identified that require repair, or if repair is not possible or not economical, replacement. The specific assets requiring replacement are not known until cyclic inspection/testing is undertaken. Asset condition data is not generally available for these assets and neither is it generally possible to undertake major repairs.

3.4 Deterioration and failure modes

Some of the common causes of deterioration are described below by asset class. These failure modes are age related in that the impact of use and the environment progressively deteriorates the assets over time. The rate of deterioration will depend on utilisation, location (i.e. proximity to the ocean), frequency of operation and other environmental factors. Further information on failure modes, causes, maintenance activities and replacement decision making criteria is available in relevant Asset Class Management Plans.

Distribution transformers

- Deterioration due to environmental condition and use, including external corrosion, leaking oil and deterioration of internal insulation that can lead to failure.
- Moisture ingress due to leaks that reduce insulation performance of oil, increasing susceptibility to surge (lightning) related internal flashovers.
- Over utilisation resulting in deterioration of internal components and eventually failure.
- Over utilisation (above rated capacity) can result in destruction of the asset and potentially fire (i.e. under rated distribution transformer).
- Direct lightning strikes that cause internal insulation, tank or bushing damage.
- Severe weather events such as tropical storms, tropical lows and cyclones.

Distribution switches

- Deterioration due to environmental condition and use, including external corrosion, leaking oil/gas and arcing during operation damaging contacts.
- UV degradation of insulation and plastic components in switch mechanisms and arc suppressors.

- Deterioration of mechanical and operational parts due to environmental conditions (corrosion) or high number or frequency of operations.
- Deterioration of insulation performance due to ageing and a hot and humid operating environment with short annual periods of extremely dry conditions that promote the build-up of dust on insulating surfaces.
- Cable termination failures due to various causes that directly damage the switchgear.
- Direct lightning strikes that damage switchgear components.
- Severe weather events such as tropical storms, tropical lows and cyclones.

Overhead conductor

- Damage at joints or connection to insulators due to movement and vibration.
- Corrosion of metallic components (i.e. galvanised strands ACSR or steel conductors).
- Damage from direct lightning strikes causing annealing, broken strands and damage to galvanising.
- Damage from external causes such as debris during annual wet season storms, tropical lows and cyclones or contact with vegetation or animals.

Underground cable

- External causes, such as digging equipment damaging cables.
- Water ingress damaging components such as the sheathing, screening and XPLE.
- Failure of the joint due to poor installation (often compounded by environmental conditions).
- High utilisation and high ground temperatures that stress insulation, connectors and joints.
- Damage caused by fauna such as termites.

Surge arrestors

- Failures (operation) in service and due to high volume of lightning related operations.
- Direct lightning strikes that exceed the capacity of the arrestor causing internal damage.
- Deterioration of external casing resulting in flash over/water ingress/other.

Pillars

- Deterioration due to corrosion or concrete cancer due to long term exposure to high humidity environment.
- Deterioration of covers due to intense UV exposure in the Northern Territory.
- Damage caused by fauna such as termites.
- Failure of internal joints/connections due to poor installation (often compounded by environmental conditions).

3.5 Common industry practice

The assets covered by this BNI are typically referred to as 'volumetric' assets. That means, individually, each asset is low cost, but there are high volumes that need to be replaced each year, so overall the program is significant.

However, since these are simple and low value assets, there is not a lot of condition data that can economically be ascertained for condition assessments or analysis of deterioration rates. Therefore, the typical approach for forecasting future needs is a probabilistic modelling approach based on the age profile and expected life of each asset category.

Where there is a sufficiently large data sample of the age of assets at replacement, a specific distribution for the asset can be built and used for modelling. If data is not available, which is common throughout the industry, assumptions are made and the model calibrated to ensure the forecast is consistent with past practices and network needs. This provides a forecast of the volumes of assets that will require replacement each year during the forecast period. It does not forecast which specific assets will be replaced.

Actual replacements in the field are made based on condition assessments made by field crews throughout the forecast period. This ensures that only assets requiring replacement are replaced.

3.6 Project Drivers

a. Safety
Maintain the safety performance of the network, as required by the NER Objectives, through ensuring asset that have failed or are identified to be in poor condition are removed from service and replaced with safe and functioning equivalent assets.
b. Reliability (if not compliance obligation)
This program of work will ensure that the in service failure rate of assets remains consistent with the historical rate of failures and therefore assist PWC to maintain the reliability performance of the network as required by the NER Objectives.

4 Potential Solutions

To address the safety and reliability impacts of asset deterioration and failures, three options have been considered and are discussed below. The preferred option will provide the following benefits:

- Enable PWC to meet the NER objectives of maintaining reliability and safety.
- Provide an appropriate forecasting method to provide a forecast that is reflective of actual and future needs of the network.

- Be aligned to common industry practice.

5.1 Options Considered

Option 1 – Do nothing (only replace at failure)

This option proposes to reactively replace assets once they have failed but not undertake any proactive replacement of assets. This will likely result in an initial deferral of expenditure but will result in increasing replacement works in emergency circumstances as the number of assets failing in service increases due to lack of proactive replacements. This option will result in progressive deterioration of network safety and reliability.

The NER Objectives set out the requirement for PWC to maintain network reliability and safety through prudent and efficient network operations. Purposefully allowing the network to deteriorate does not comply with these objectives and is not aligned to common industry practice throughout Australia.

Since this option will not enable PWC to comply with the NER Objectives of maintaining network safety and reliability and does not align to common industry practice, this option is not recommended.

Option 2 – Continue current practice (replace at failure and identification of unserviceable condition)

Option 2 proposes to continue the current network practices that involve reactively replacing assets once they have failed and also undertaking proactive replacement of assets as they are identified, through normal cyclic inspection or otherwise, to be unserviceable.

The NER Objectives set out the requirement for PWC to maintain network reliability and safety through prudent and efficient network operations. This option will enable PWC to meet its requirement. It is also aligned to common industry practice throughout Australia.

The expenditure forecast is developed using a combination of two approaches:

- a probabilistic modelling approach for asset replacement based on the principals of the AERs Repex model; and
- a trending approach for assets where data is not available, or appropriate, for probabilistic modelling.

The detail of this model is attached in Appendix A. The model was developed to provide a conservative forecast that reflects the future needs of the network given the age profile and other planned replacement activities. Multiple forecasting approaches have been assessed and the preferred method provides a valid forecast that is consistent with past expenditure and changing condition of the network (using age as a proxy).

This option is in line with industry practice. And will enable PWC to maintain network safety and reliability. The total cost for the next regulatory period FY20 to FY24 is $36.05 (real FY18). This option is recommended.

Option 3 – Change asset management approach to meet new service standard requirements

This option proposes to change PWC's approach to inspection and replacement of the distribution assets with the intent of changing the network performance outcomes such as reliability.

Improving network performance outcomes typically requires increased expenditure in Capex and Opex to replace more assets and/or to increase the frequency of inspection to identify assets prior to failure. Currently network performance is meeting targets set by the Utilities Commissioner and generally meeting customers' expectations. Under the new Electricity Industry Performance Code, proposed targets will be more onerous and present challenges to the business to achieve consistent or improved performance at the same or lower cost, which is a clear expectation of our customers based on our engagement program.

While customers do support improving reliability to poorly served customers, broad changes to asset replacement criteria proposed in this option will not achieve this efficiently.

This option is not recommended as it does not efficiently improve reliability in areas of poor network reliability.

5.2 Options summary

An analysis of the non-cost attributes for each option has been completed using the multi-criteria analysis method. The attributes are selected considering major risks and priorities to achieve Project Objectives. A weighting is allocated to each, totalling 100%. Each attribute is given a score out of 5 (from 1 – Fails to satisfy, to 5 – exceeds requirements); the score is then multiplied by the relevant weighting to give the weighted score that is summarised in Table 2 below.

Table 2 Non-Cost Attributes Comparison

	Technical & System Risk	Stakeholder Risk	Environment Risk	Commercial	
Criteria	Reliability	Safety	Oil Leaks/Fires	NPC	Weighted Scores
Weighting (%)	20	30	10	40	100
Option 1	0.2	0.3	0.1	0.4	1.0
Option 2	1.0	1.5	0.3	1.2	4.0
Option 3	0.6	0.9	0.3	0.4	2.2

5.3 Preferred Option

Option 2 is comprised of two components: replacing assets that have failed in service, and replacing assets that are identified to be in poor condition during cyclic inspection programs. Current replacement requirements based on asset condition and safety that have driven replacement activity in the current period will be maintained, and where possible optimised. Other targeted programs to improve reliability to poorly served customers will be proposed and justified separately. These two approaches will therefore continue to be the mechanism through which network performance targets will be met.

Based on the preferred option, two different approaches have been applied to forecast replacement requirements.

Reactive replacement to address asset failure

The trend of asset failures in service has been used to forecast future replacement requirements for assets where insufficient data is available to undertake probabilistic modelling or where network experience demonstrates trending to be an appropriate indicator of future need for those assets. A flat trend using historical data based on the P50 level or a line of best fit (using linear regression) has been used depending on the asset type.

Proactive replacement to address deteriorated condition

A probabilistic approach has been applied to forecast the expenditure required for asset replacement due to condition and in service failures. This approach is forecast based on the age profile, conditional probability of failure, historical volumes and historical unit costs.

The forecasting model is explained in detail in Appendix A.

The BNI excludes the replacement or remediation of poles. Due to the steel construction of poles, PWC does not experience high volumes of asset failures or the need to replace deteriorated assets on a network wide recurrent basis, so it is not appropriate to forecast replacement needs using this approach. A specific program to address a specific emerging failure mode for poles in the Alice Springs region has been established and is excluded from the replacement forecasts covered by this BNI.

Table 3 Forecast replacement expenditure ($'M, real FY18)

Reason	FY20 ($'000)	FY21 ($'000)	FY22 ($'000)	FY23 ($'000)	FY24 ($'000)	Total ($'000)
Trending	$127	$128	$128	$127	$128	$638
Probabilistic	$6,165	$6,542	$7,009	$7,547	$8,144	$35,407
Total	$6,292	$6,670	$7,137	$7,674	$8,272	$36,045

NOTE: Due to correction of an assumption in the model, the forecast expenditure requirement has increased from $35.7 million that was submitted in the Regulatory Proposal to $36.0 million, an increase of approximately $0.35 million.

The unit rates used in the forecasting model are based on an analysis of historical costs of asset replacements. The unit rates were found to be aligned to those reported in the AER Category Analysis RINs by peer businesses.

The combination of the proactive and reactive works will ensure network reliability and safety will be maintained.

5.4 Non-Network alternatives

Due to the type and function of the assets within the scope of this program, there are no non-network alternatives or solutions that can be implemented in place of direct asset replacement with like for like or modern equivalent assets.

5.5 Capex/Opex Substitution

All network assets are inspected on a cyclic basis by field crews to assess condition. However, due to limited maintenance or repairs that can be undertaken on these types of assets, it is not possible to extend their life through increased maintenance and therefore capex opex substitution is not a viable solution for these asset types. Typically, once the asset has deteriorated sufficiently and reached end of life it can only be replaced.

5.6 Contingent Project

This project does not qualify as a contingent project as defined by the NER Clause 6.6A.1.

5 Strategic Alignment

This program aligns with the Asset Objectives defined in the Strategic Asset Management Plan (SAMP) and Asset (Class) Management Plans (AMP). The capital investment into the distribution assets outlined in this program will contribute to the Corporation achieving the goals defined in the boards Strategic Directions and SCI Key Result Areas of Health and Safety and Operational Performance.

6 Timing Constraints

There are no time constraints on this program of works. Replacement timing is an output of the forecasting model described in Appendix A.

7 Expected Benefits

Driver	Benefit	Measure
Asset Renewal	Aged assets affecting reliability will be identified as part of performance analysis and replaced prior to failure.	SAIDI and SAIFI performance of individual feeders.
Service Improvement	Improved reliability to poorly served customers.	SAIDI and SAIFI performance of individual feeders.
Social / Environmental	Prevent deterioration of current reliability performance	SAIDI and SAIFI performance of individual feeders.

8 Milestones

Investment Planning	Project Development	Project Commitment	Project Delivery	Review
01/2018	06/2018	07/2019	06/2021	09/2021

The program delivery is scheduled to run over 5 years from July 2019 to June 2024. A program review will be held at the end of the program as well as interim reviews at the end of each financial year.

9 Key Stakeholders

Stakeholder	Responsibility
Internal governance stakeholders	Executive General Manager Power Networks
	Group Manager Service Delivery
	Chief Engineer
	Senior Manager Asset Management
Internal Design Stakeholders	Manager Asset Quality and Systems
	Manager Test and Protection
	Manager Field Services
	Manager SCADA and Communications
External – Unions and public	ETU
	Local Councils
External regulators	Utilities Commission
	Australian Energy Regulator

10 Resource Requirements

No specific resources have been identified to reach the next milestone. Identification of assets to be replaced will be undertaken during the cyclic inspection and maintenance activities of the business and is considered business as usual, including the ongoing refinement of repair/replacement criteria, maintenance strategies and delivery efficiency improvements.

11 Delivery Risk

This is a standard program of works that has been implemented historically and it is forecast to continue at volumes consistent with historical practice. Therefore, there is no delivery risk associated with this program of works.

12 Financial Impacts

13.1 Expenditure Forecasting Method

This program has been forecast using a model developed by PWC using historical replacement data and the expected lives of the assets. The model is based on the same principals as the AER's Repex model. A description of the model is attached in Appendix A.

13.2 Historical and forecast expenditure

This program of works is a subset of the total repex forecast. Historically the volumetric assets have been replaced under the volumetric pooled asset replacement program as well as by other projects that targeted specific regions or asset types that were demonstrating specific failure modes.

To ensure a like for like comparison, Table 4 below sets out the historical total repex, then splits it out into the low value asset classes. Not all 'volumetric' type assets were replaced as part of the volumetric pooled asset program. A number of assets were replaced through specific programs that targeted asset type or location to address identified issues. Table 4 provides another adjustment to remove these assets so the historical expenditure on volumetric assets could be developed on the same basis as the forecast is being made.

In calculating the adjustment, PWC identified the programs of work or types of assets that will not be continued in the next regulatory period. The following expenditure items were removed from the historical expenditure for the purpose of establishing the historical expenditure on the same basis as the forecast:

- Asset replacements that were previously undertaken as part of the Pooled Asset programme but have been separated out into their own programmes for the forthcoming regulatory period, for example, the Northern Suburbs Cable Replacements.
- Assets with type issue are expected to be fully removed from the network prior to the start of the next regulatory period.
- Assets which do not have failure modes that are suitable for modelling using the Pooled Asset modelling approach were not included in the model and the historical costs were removed, for example, poles and cross arms.

Table 4 Historical expenditure breakdown ($FY17) including 2017-18 forecast

Description	2013-14 ($'000)	2014-15 ($'000)	2015-16 ($'000)	2016/17 ($'000)	2017/18 ($'000)
Total repex	$47.8	$46.9	$47.8	$30.1	$24.1
Low value asset pool	$7.1	$11.6	$11.4	$11.1	$11.1
Low value asset pool (% of total repex)	15%	25%	24%	37%	46%
Adjustments	$2.43	$6.67	$5.29	$5.20	$5.78
Adjusted low value asset pool	$4.66	$4.88	$6.06	$5.88	$5.32
Adjusted low value asset pool (% of total repex)	10%	10%	13%	20%	22%

The historic and forecast expenditures are shown by RIN category in Figure 0.1. Overall, the figure shows that forecast expenditures follow the uplifting trend of historical expenditures, consistent with the increasing failure rates associated with aged assets and the increased volume of assets entering the wear out phase as shown in Figure 3.

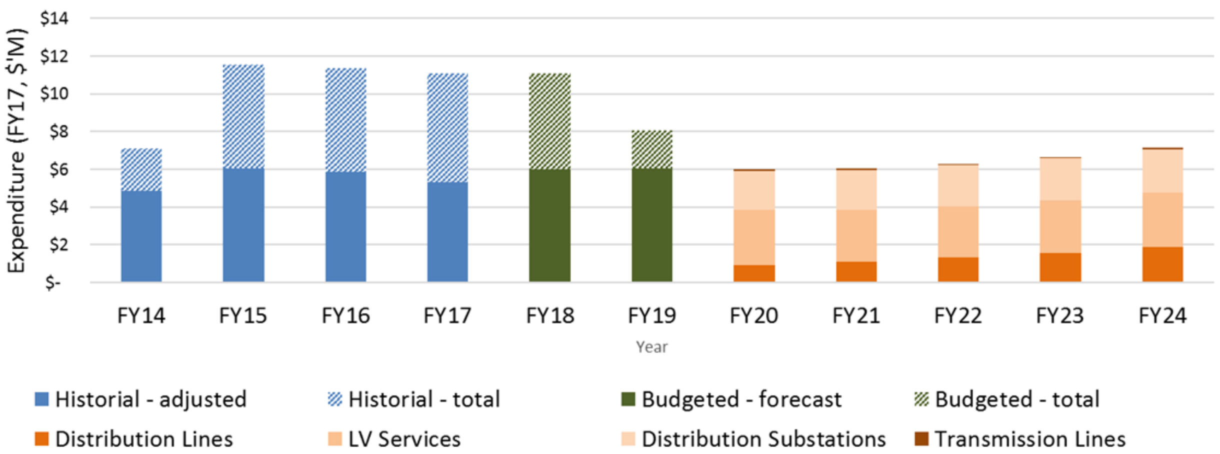

Figure 3 Historical and forecast expenditure by RIN category ($m, 2017)

The outputs of the model, in terms of expenditure, are shown in summary in Table 5. It shows that only the expenditure in the distribution transformer and switchgear categories is material (greater than $5 million).

Table 5 Forecast replacement expenditure by asset type ($FY17)

Asset	2019-20 ($'000)	2020-21 ($'000)	2021-22 ($'000)	2022-23 ($'000)	2023-24 ($'000)	Total
Overhead Conductors	$275	$351	$446	$564	$709	$2,345
Pole Top Structures	$24	$24	$24	$24	$24	$120
Underground cable	$582	$688	$817	$975	$1,167	$4,229
Service lines	$76	$76	$76	$76	$76	$380
Transformers	$2,710	$2,777	$2,887	$3,013	$3,140	$14,527
Switchgear	$2,162	$2,225	$2,293	$2,363	$2,433	$11,476
Other - Connectors	$16	$17	$18	$18	$19	$88
Other - Surge arrestors	$11	$11	$11	$9	$9	$51
Other - Pillars	$437	$501	$566	$632	$695	$2,831
Total Expenditure	**$6,292**	**$6,669**	**$7,138**	**$7,674**	**$8,272**	**$36,047**

The forecast for each individual category shows an immaterial increase, but in aggregate there is an increase of $1.9 million from FY20 to FY24. This is consistent with the increasing number of assets approaching the end of their serviceable lives as discussed in section 3.

The forecast is driven by the assets modelled using the probabilistic approach. This is largely due to more information being captured for higher value assets which enables more advanced modelling approaches to be applied.

The transformer and switchgear asset categories account for 72% of the total replacement expenditure forecast by the Pooled Asset model for the next regulatory period, and will result in an increase of $700 thousand (14%) in FY24 compared to FY20. This does not appear to be a material or unreasonable increase considering the asset age profile and recent experience of emerging type issues with existing assets and replacement trends in the historical replacement volumes.

The underground cables are the next largest contributor to the increasing trend. They are forecast to increase from $582k in FY20 to $1,169k in FY24. Again, although this appears to be a large increase when considered as a percentage, it is only a $586k increase in dollar terms. However, given that the number of assets expected to be entering their wear out phase during the next regulatory period will increase from 22km to 64km (refer to

Appendix A), the forecast is considered to be conservative.

13.3 Validation

The replacement forecast has been validated against three different forecasting approaches and by using scenario analysis. Refer to Appendix A for further details.

13.4 Capex profile

The Capex profile for this program includes no expenditure other than Project Delivery. Individual relay design and replacement is a routine business task.

The capex in the table below is in $2017-18, and is excluding capitalised overheads and cost escalation

Phase	2019-20 ($'000)	2020-21 ($'000)	2021-22 ($'000)	2022-23 ($'000)	2023-24 ($'000)	Total ($'000)
Investment Planning						
Project Development						
Project Commitment						
Project Delivery	$6,292	$6,669	$7,138	$7,674	$8,272	$36,045
Review						
Total	**$6,292**	**$6,669**	**$7,138**	**$7,674**	**$8,272**	**$36,045**

13.5 Opex implications

This is an ongoing program of works and the inspection and testing of assets is undertaken on a cyclic basis. This opex program has been undertaken during the current period and therefore there is no opex step change expected due to this program.

13.6 Variance

This forecast is an increase of an average of $1.7 million per year compared to the current period. This is due to the aging of the asset fleet and assets installed during reconstruction after Cycle Tracey in 1974 and the expansion of the network in the early 1980's approach the end of their serviceable lives.

Appendix A

Condition and Failure Based Replacement Pool Forecasting Methodology

RM8 Ref: D2017/493389