PowerWater

Program Business Need Identification

Power and Water Corporation

CONTROLLED DOCUMENT

NPR

Protection Relay Replacement

Proposed:	Approved:
Wing Chan	Michael Thomson
Manager Protection Assets	Chief Executive
Power Networks	Power and Water Corporation
Date: 4/12/2017	Date: 6/12/2018

	D2018/43399	
Djuna Pollard		
Executive General Manager	Finance Review	PMO QA
Power Networks	Date:05/12/2017	Date: / /20
Date: 5 December 2017		

1 Program Summary

Program Name:	Protection Replacement Program		
Program No:	NPR	**SAP Ref:**	
Financial Year Commencement:	2019/20		
Business Unit:	Power Networks		
Project Owner (GM):	Djuna Pollard	**Phone No:**	08 8985 8431
Contact Officer:	Wing Chan	**Phone No:**	08 8924 5214
Date of Submission:		**File Ref No:**	
Submission Number:		**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 Chief Executive note the proposed five year protection replacement program for an estimated budget of $3.8M, and approve the inclusion of this program into the SCI for this amount, with a corresponding completion date of June 2024.

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

Protection relays are generally associated with a circuit breaker or transformer and are used to monitor the network voltages and currents. If a fault condition is detected, the relay will operate to open a circuit breaker to interrupt the fault, protect major assets and ensure the safety and continued operation of the rest of the network. If a protection device fails to operate, the next device upstream will operate to stop the fault, however, the operation time will be longer. The longer interruption time increases the risk to public, particularly if a fault is related to public contact with equipment. The number of customers affected by the operation will be larger as upstream protection will generally result in the loss of supply to a large proportion, if not all, customers supplied from a zone substation.

There are 1,305 relays on the network as shown in as shown in Table 1. Older relays are generally electromechanical or analogue electronic (static) devices that provided a single protection function. Modern devices are microprocessor based (digital) and provide multiple protection functions within each device as well as diagnostic capabilities. Modern relays are also able to communicate with the SCADA system to provide operational information to System Control.

Electromechanical relays installed in the 1980’s are generally approaching the end of their expected serviceable lives. However, the fleet as a whole is performing reliably with only a few replaced each year due to loss of calibration or failure. This aligns with experience of other distribution utilities in Australia.

Relays have reasonably long design lives, as shown in Table 1. The fleet age profile is shown in Figure 1. The small population of electromechanical relays have reached the end of their expected serviceable lives and need to be replaced. The more complex static relays, such as GEC MBCH and ABB RADSB, have also reached the end of their expected serviceable lives and they have been made obsolete by the manufacturers. The early generations of digital relays, such as GEC Quadramho, ABB Razoa and Alstom MCGG, have reached the end of their expected serviceable lives and they have been made obsolete by the manufacturers.

The majority of digital and simple static relays are still relatively young due to a large volume of substation replacement works during the past five years.

Table 1: Overview of protection relay fleet

Type	Number	Percentage of fleet	Expected life (yrs)
Digital	863	64.6	20
Static	439	32.9	20
Electromechanical	3	0.2	40
Total	1305	100	

Note: Excludes non-regulated assets.

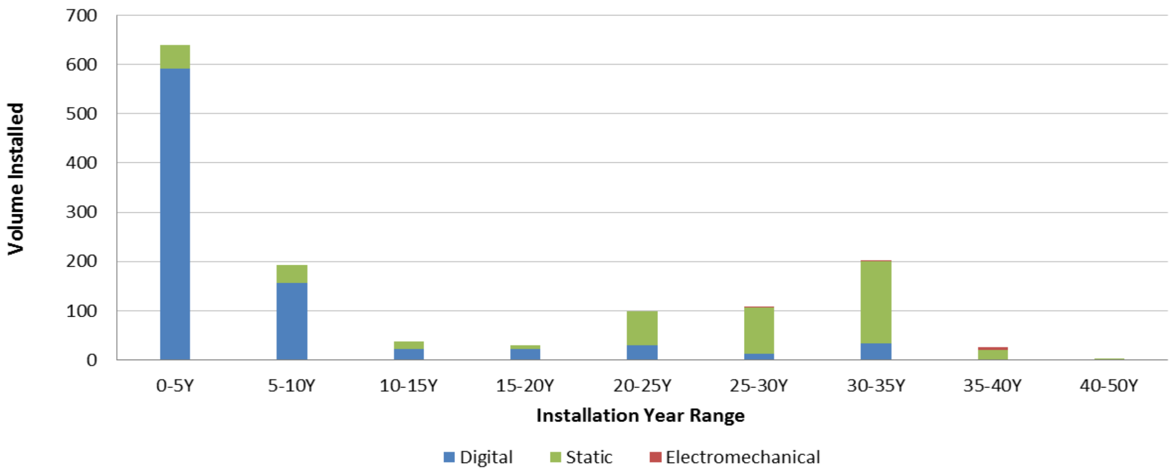

Figure 1: Protection relay age profile

Inspection and testing is undertaken in accordance with the maintenance policy which sets out the type and frequency of inspection and testing to be undertaken. The testing schedule is coordinated to align with major asset inspections or works.

If a relay is found to fail testing a report is raised to the Protection Engineers to determine the most appropriate action to be taken on a case by case basis. Where possible, relays are replaced under warranty; however this does not negate the need for replacement action at the time of failure.

Current and emerging issues that have been identified on the network are detailed below. Further information and analysis is contained in the Protection Asset Class Management Plan.

- Electromechanical relays demonstrating slower operating times than required. Once they cannot be reliably recalibrated they need to be replaced. Historical data shows this to be at a rate of approximately three per year, excluding those replaced as part of substation replacement projects. The in-house skill and capability to reliably recalibrate or repair these relays is no longer available.
- Complex static relays are often found to be operating outside the rated tolerance or non-functional. The cause of failure is difficult to identify and generally not repairable.
- The older digital relays have reached the end of their expected serviceable life and they have been made obsolete by the manufacturers. They also have poor communication interface which makes them harder to work with and diagnose.
- To maximise the useful life of relays made obsolete by manufacturers, PWC replaces some relays in the fleet to generate spares for the remaining fleet. These are used to perform like-for-like replacements when like relays fail in-service.
- Component failures in digital relays such as current elements, output contacts, communications module faults and power supplies failure can result in relay replacement. Some relays are modular and only the failed component module requires replacement. Approximately three digital relays per year are replaced due to these common failures.

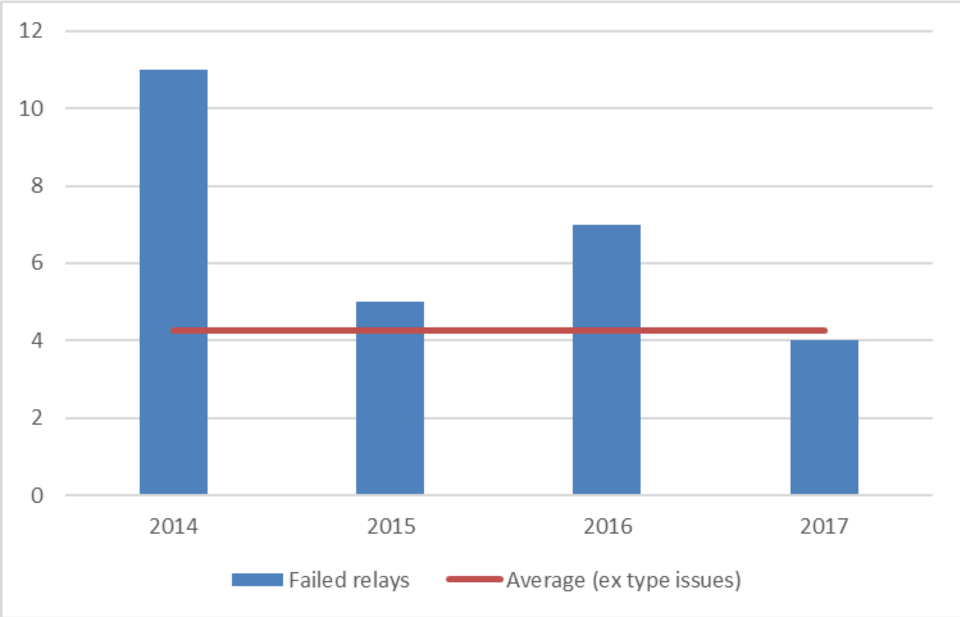

Figure 2: Faulty relays found during testing and replaced

The following relay models have been identified as requiring replacement as they have reached end of design life, have been made obsolete by manufacturers and have no spares available:

- MCGG: distribution feeder/transformer OCEF Static relays
- RADSB, RADSE, MCBH: transformer differential – the new digital relay will provide the transformer differential, restricted earth fault, circuit breaker failure check, overcurrent, earth fault functions, etc.
- RAFSE, RAZOA, Quadramho: distance protection – the new digital relay will provide distance protection, circuit breaker failure check functions, etc.
- Replace bus tie relays : the new digital relay will provide CB management, syncheck and overcurrent / earth fault functions.
- There is also a need to replace relays that fail while in operation. Historical data shows that there has been an average of 4 relays per year that have failed and have required replacement in unplanned circumstances. This number excludes SPAJ relays for which Power Networks has sufficient spares for like for like replacement.

3.1 Project Needs

a. **Safety**
Maintain the performance of the network protection to arrest fault currents, over voltages, sensitive earth faults and other fault conditions. Remove faults as quickly as practicable. Maintain grading of the protection across all network devices to ensure the most rapid response to faults. Lines down present a risk to public. Protection is critical to detecting those faults and acting to interrupt supply by opening the circuit breaker.
b. **Compliance**
Maintain compliance with the Power Networks Network Technical Code And Network Planning Criteria. Specifically section 2.9 Protection Arrangements, which details requirements for safe and reliable management of protection systems to maintain a safe, reliable and secure system.
c. **Reliability (if not compliance obligation)**
If a protection device fails to operate, the next device upstream will operate to stop the fault, however, the operation time will be longer and the number of customers affected by the operation will be larger. Allowing all relays to remain in service until they functionally fail is not an acceptable practice and would result in poorer reliability outcomes for customers.

4 Potential Solution

4.1 Options Considered

Option 1 – Replace at failure only

This will reactively replace failed or poor performing relays. This option ensures the maximum life of the relay is achieved. However this option increases the risk to equipment and people.

If a relay fails between maintenance intervals, a fault will be cleared by upstream protection device resulting in a slower clearing time and wider outage than otherwise would have happened. Slower clearing times greatly increase the energy transferred during the fault and resultant damage to equipment or people if interacting with the failed equipment or causing the fault (e.g. contact with overhead lines or failures during equipment switching).

Option 2 – Targeted replacement program

The targeted program will replace relays with an increasing likelihood of failure that are not repairable and are obsolete with no spares available.

Option 3 – Age based replacement (replace at end of design life)

This will likely to result in early replacement of assets and is unlikely to be the most economic option but results in the lowest residual network risk. This option is suitable for relays with a high consequence of failure.

4.2 Preferred Option

The preferred approach is a combination of all three options, maximising the life of relays with a low consequence of failure, and targeting relays with known issues or higher consequence of failure.

The protection relay fleet is tested periodically to verify the functionality. The frequency of testing depends on relay type and classification. The relay will be replaced by an identical relay or an equivalent if found to be defective. In addition, when type/batch issues are identified for a batch or relay model, targeted replacement programs will be established as required. Currently there are no known type/batch issues that require an immediate targeted replacement program.

Total forecast for this option is summarised in Table 3 and Table 4 below. Volumes do not include relays from Berrimah ZSS, and other smaller ZSS, planned for replacement during the same period for 2019/20 to 2023/24. These replacements are included in specific business cases for replacement of those substations.

Table 3: Forecast replacement volumes

Reason	FY20	FY21	FY22	FY23	FY24	Total
Planned	9	9	9	9	8	44
Unplanned	4	4	4	4	4	20
Total	13	13	13	13	13	64

Table 4: Forecast replacement expenditure ($'M, real FY18)

Reason	FY20	FY21	FY22	FY23	FY24	Total
Planned	0.58	0.58	0.58	0.58	0.58	2.9
Unplanned	0.18	0.18	0.18	0.18	0.18	0.9
Total	0.76	0.76	0.76	0.76	0.76	3.8

Expenditure is based on a bottom up build of costs including design, installation and commissioning, materials and SCADA. Relays in Alice Springs include an additional cost for travel to site and allowances, based on a crew of two technicians per relay. Cost estimates are shown in Appendix A.

4.3 Non Network alternatives

Due to the type and function of the assets in the protection relay asset category, 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.

4.4 Capex/Opex substitution

In BAU, maintenance is only undertaken for digital relays by the manufacturer when still in warranty. Otherwise, relays can only be replaced. Investigations into the protection settings or acceptability of the relay timing of operation may also be undertaken to determine if a relay needs to be replaced.

Capex/Opex substitution is not a viable solution for this asset type as once the asset is outside of Vendor Support, there is no repair that can be undertaken.

4.5 Contingent Project

This project does not qualify as a contingent project as defined by the NER Clause 6.6A.1. It is required for the continual safe and reliable operation of the network and is not contingent based on an external driver and does not exceed $30 million or 5% of the forecast capital budget forecast.

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 Protection infrastructure 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 specific timing constraints affecting the delivery of this program. The planned replacement of relays that are at end of life and no longer supported by vendors or spares maximises the life without increasing the risk associated the failure of critical protection systems.

7 Expected Benefits

Driver	Benefit	Measure
Renewal/ Replacement	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	Improved reliability to poorly served customers.	SAIDI and SAIFI performance of individual feeders.

8 Milestones (mm/yyyy)

Investment Planning	Project Development	Project Commitment	Project Delivery	Review
01/2018	-	01/2019	06/2024	09/2025

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 5 year 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

Stakeholder	Responsibility
Internal Design Stakeholders	Manager Protection
	Manager Test & Protection Services
	General Manager System Control
	Manager SCADA and Communication Services
External – Unions and public	ETU
External regulators	Utilities Commission
	Australian Energy Regulator

10 Resource Requirements

Not applicable. Resourcing requirements for this program are considered Business as Usual and will be incorporated into the development of Category C Business Cases for each individual replacement.

11 Delivery Risk

This is a standard program of minor project works that has been ongoing for the previous two regulatory periods. Major asset replacement projects have impacted on the delivery of specific relay replacement projects historically, however this is not expected to have a significant impact in future due to the overall reduction of the replacement capital forecast.

12 Financial Impacts

12.1 Expenditure Forecasting Method

The program of works has been forecast based on a bottom up build of individual relay replacement costs and trending of historical asset failures.

Unit replacement costs were calculated based on recent historical actual costs where possible, as well as relay cost quotes. The unit costs are by relay type and region, including all installation, materials (including SCADA and communications connectivity) and commissioning required.

The historic trend of failures has been based on a search of all asset test reports that have resulted in the need for replacement as well as records of failures that resulted in immediate replacement by field crews.

The forecast excludes replacement undertaken as part of a large capital work project, such as the upgrade of Berrimah ZSS.

12.2 Historical and Forecast Expenditure

The vast majority of relay replacements in the previous period have been completed as part of major substation upgrade or replacement projects. Figure 2 - Historical and Forecast Expenditure shows only expenditure for minor projects for specific relay replacements.

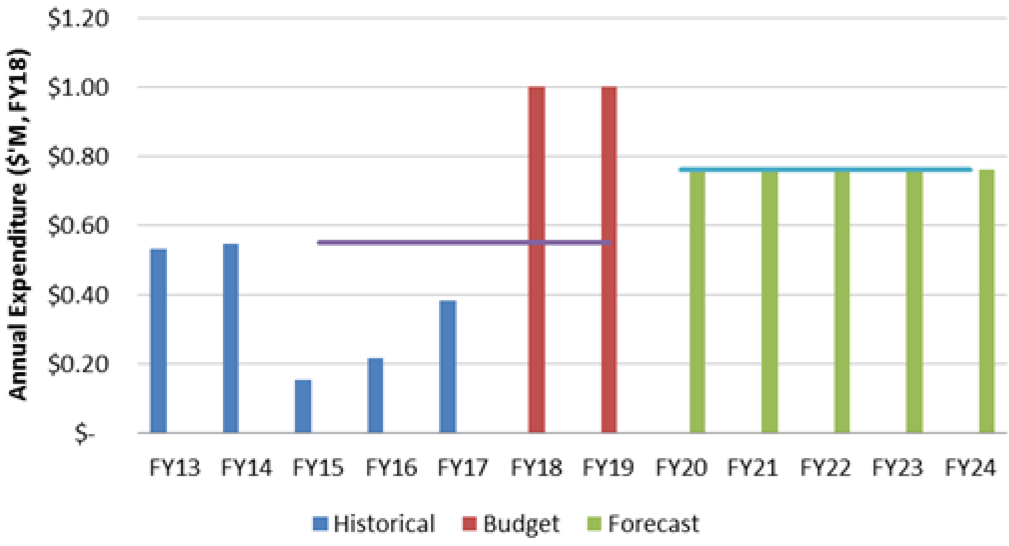

Figure 2 - Historical and Forecast Expenditure

12.3 Validation

The replacement forecast has been validated at a high level against the number of relays that have typically been replaced each year based on planned replacements and in-service failures.

12.4 Capex Profile

The Capex profile for this program includes no expenditure other than Project Delivery. Project development costs are minimal for each individual project and will be included in the Category C Business Cases on a case-by-case basis. Individual relay design and replacement tasks are routine business tasks for the Protection Asset Management team.

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	760	760	760	760	760	3,800
Review						
Total	**760**	**760**	**760**	**760**	**760**	**3,800**

12.5 Opex Implications

The inspection and testing of relays is undertaken on a cyclic basis as part of the Preventative Maintenance Program to confirm protection system integrity. This maintenance has been undertaken during the current period and therefore there is no opex step change expected as a result of the replacement of the small volume of relays being replaced as part of this capital.

12.6 Variance

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.

Appendix A

1 Replacement Cost Estimates

The following table summarise the estimated cost of replacement for the types of relays targeted for replacement, including consideration of the region in which they are located.

Relay	Replacement Proposed Relay+	Number to be Replaced	Estimated Unit Costs	
			(Darwin Region)	(Alice/Tennant Creek Region)
RADSB(TF X) +MFAC34(TF Y) or SPAJ or MCGG	T60,7UT633,C60	7	$222.4K	$266.9
MCGG51(Distribution feeder)	SEL751	9	$45.3k	$54.4k
DDR2000	DDR4000	6	$66.3	$79.6
2SY110, MVTT14(Bus Tie)	C60	4	$72k	$86.4k
11kV, 22kV Bus Tie	SEL751A	4	$42	$50.4