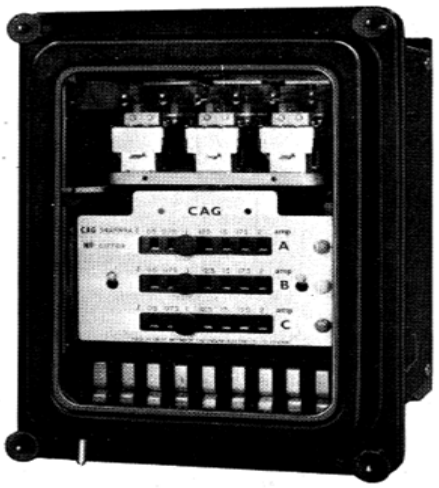


SUBSTATION PROTECTION RELAY REFURBISHMENT

Program PS008 Business Case 2017/18 – 2018/19, Stage 2

Prepared by Strategy and Network Planning

August 2017

Endeavour Energy

REVIEW AND APPROVAL SCHEDULE

Responsibility	Position	Name	Signature	Date
Authored	Network Investment Program Engineer	Sanath de Fonseka		08/08/17
Reviewed	Senior Renewal Project Development Engineer	Jonathan Cook		8/8/17
Reviewed	Network Investment Planning Manager	Manoraj Jayasekara		08/08/2017
Endorsed	Manager Asset Strategy and Planning	Peter Langdon		8.8.17

CONTENTS

1.0 EXECUTIVE SUMMARY

This business case seeks approval for the expenditure to replace protection relays in zone and transmission substations throughout the network as the next stage of the ongoing relay replacement program PS008. This business case was initiated by a Statement of Asset Need from Asset Standards and Design which identified relays that are experiencing an increasing number of failures which is evidence of them reaching the end of their life.

Relays that increasingly operate inappropriately place a greater reliance on the backup protection schemes that are in place and/or cause unnecessary outages to customers.

This business case includes the replacement of 271 protection relays at 37 transmission and zone substations over the two year period from 2017/18 – 2018/19.

The total cost of the works is $6.2 million in real terms and $6.4 million in nominal terms. A further risk based contingency of $0.5 million being 8% of the estimated project cost is proposed to allow for unforeseen cost increases due to the works being conducted in aged substations which contain hazardous materials such as asbestos.

The Portfolio Investment Plan (v8.3) includes a provision for $4.1 million under program PS008 over this period. Further funding will be provided in the 2018/19 PIP to provide for the works in the 2018/19 year.

Accordingly, it is recommended that:

- A capital expenditure of $6.4 million to replace 271 protection relays at 37 transmission and zone substations throughout the network over the period of 2017/18 – 2018/19 as detailed in this business case be approved;
- A contingency sum of $0.5 million, representing approximately 8% of the estimated cost of the project to cover unforseen events be approved;

The project estimate, including the contingency sum, totals $6.9 million

2.0 INTRODUCTION

2.1 PURPOSE

This business case seeks the approval for the expenditure for the next stage of the program PS008 to replace protection relays which have reached the end of their life in zone and transmission substations throughout the network during 2017/18 – 2018/19. This is the second stage of works in 2017/18 – 2018/19 and is in response to a Statement of Asset Need (SAN) provided by Asset Standards & Design which identified relays which are experiencing an increasing number of failures, indicating that they are reaching the end of their life and requiring renewal in the short term. Refer to Appendix A for further detail of the SAN documents.

2.2 BACKGROUND

Within Endeavour Energy's zone and transmission substations there are currently over 18,000 protection relays in service which are covered by this program, PS008.

The function of these relays is to interpret signals from measurement devices such as instrument transformers to identify faults in the network. Once a fault has been detected they signal a circuit breaker to clear the fault. It is important that this process occurs reliably to reduce the risk of exposure of network faults to the public as well as workers and to minimise damage to the network caused by the passage of fault current.

It is also important that a relay does not suffer from spurious mal-operations (i.e. they should not operate when a network fault is not present) as this may cause unnecessary outages to customers.

In Endeavour Energy's network there are a number of generations of protection relays in service reflecting the age and development of the network over time. These include:

- Electromechanical relays;
- Electronic relays;
- Numerical relays.

An age profile for relays in Endeavour Energy's network based on commissioning dates is shown in Figure 1 below.

2.2.1 ELECTROMECHANICAL RELAYS

Between the 1950s and 1980s electromechanical relays were installed in the network. These relays rely on induction coils and moving parts which react to signals from instrument transformers. These relays are mechanically complex but have limited functionality and settings which do not provide flexibility to adjust to changes in the protection requirements of the network.

The life expectancy of electromechanical relays 45 years. Therefore many are currently approaching or have exceeded their service life.

2.2.1 ELECTRONIC RELAYS

During the 1990s electronic relays were beginning to be installed in the network. These relays use electronic components to simulate the characteristics of the earlier electromechanical relays and have the same limited functionality and settings. These relays have proven to be robust and reliable with life expectancy of 25 years.

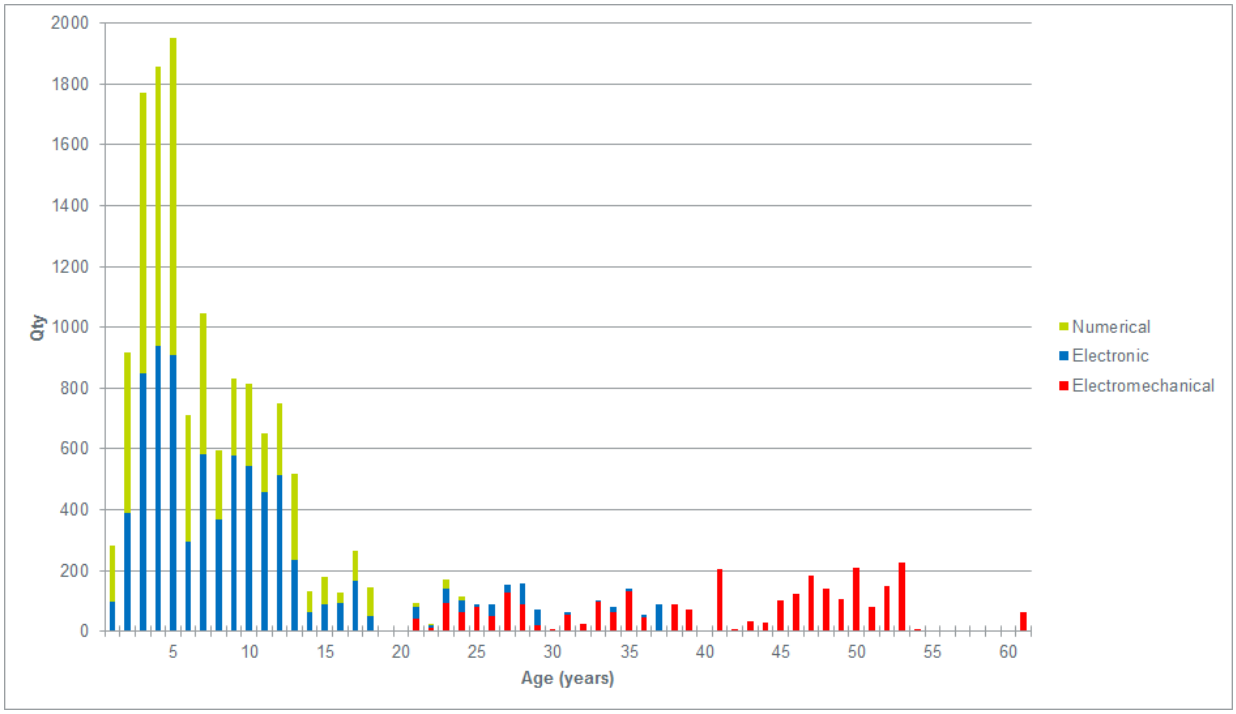
2.2.2 NUMERICAL RELAYS

Over the last 15 or so years numerical relays have been installed in Endeavour Energy's network. These relays use microprocessors to provide greater flexibility, accuracy,

performance and functionality than what could be provided by electromechanical or electronic relays.

The life expectancy of numerical relays is 20 years. This is shorter than their predecessors due to the complex microprocessor based electronics used. Therefore, many of the older numerical relays in the network are approaching the end of their life.

FIGURE 1 – RELAY AGE PROFILE



2.3 RENEWAL STRATEGY

Endeavour Energy has in place a strategy of replacing individual protection relays or complete protection schemes with numerical relay schemes based on an assessment of the risks posed by these relays and schemes taking into consideration:

- The failure history and probability of failure of that relay;
- The impacts of the type of failure considering the location the relays are installed;
- The level of backup protection provided by other relays;
- Whether or not the relay has watchdog supervision and a failure alarm;

Refer to the SAN in Appendix A for further detail of the risks posed by each relay and the primary and secondary benefits provided by their replacement.

2.3.1 PROBABILITY OF FAILURE

The probability of failure for a particular type of relay increases as it ages. This probability is calculated based on historical failures recorded in the Ellipse database.

2.3.2 IMPACT OF FAILURE

The impact of failure depends on the part of the network that the relay protects and the consequence of the relay failing to operate.

2.3.3 LEVEL OF BACKUP PROTECTION

The greater the degree and reliability of backup protection that is present reduces the reliance the network has on a particular relay. Therefore, this reduces the likelihood of the potential impact from occurring upon failure of the relay.

2.3.4 FAILURE ALARMS

If the relay has watchdog supervision and a failure alarm, system operations will be informed when a relay fails whilst in-service. This will provide an opportunity for the organisation to repair the failed relay before a fault is encountered.

2.3.5 RELAY REPLACEMENT

The decision to replace a relay is reached when its probability of failure has increased so that the risk of the impact occurring outweighs the cost to replace the relay. Refer to Appendix A for further detail and examples of different types of relays.

2.3.6 RELAY TYPES WITH LOW POPULATION

It is not practical to assess failure rates of relays where there are only a few of that type in the network. It is recommended that an age based renewal strategy is taken for these relays before they are expected to reach a high risk of failure.

2.4 REPLACEMENT CATEGORIES

Based on the risks shown above certain categories of relays have been identified for renewal. These are summarised below.

2.4.1 HIGH FAILURE RATE RELAYS

This group of relays are relays that are displaying an increasing rate of failure in recent years. This has been determined by analysing records of defects and failures of the relays on ellipse entered in the last five years. These relays have a high probability of failure when required to operate and is risk of resulting in an uncleared fault resulting in damage to the network.

2.4.2 RELAYS WITH NO REDUNDANCY

This group of relays are relays that are distribution feeder relays with no backup relay. In the event that these relays fail to clear a fault the upstream transformer circuit breaker is required to operate. However the transformer relay cannot account for the entire length of the feeder and faults on the ends of the feeder will remain uncleared resulting in safety issues and damage to the feeder.

Relays in this category are required to maintain a very low failure rate and to avoid premature replacement of future relays at these sites it is recommended that these single relay protection schemes are replaced by a duplicated relay protection scheme.

2.4.3 RELAYS FOR 132KV FEEDERS

This group of relays are relays that provide protection for 132kV feeders. All 132kV feeder protection schemes contain duplicate relays and therefore have good levels of backup. However, if the protection scheme fails to clear faults there will be major impacts to large parts of Endeavour Energy's network as well as the networks of other utilities. It has been found that it is not acceptable for these relays to have a failure rate of more than 1% per event.

2.4.4 AGED RELAYS WITH LOW POPULATION

Relays in this category have been nominated for renewal due to their age suggesting they are approaching end of life.

2.5 FURTHER BENEFITS OF REPLACEMENT

Further benefits associated with the replacement of the relays noted above are discussed below.

2.5.1 REDUCED SAFETY RISK

The replacement numerical relays will reduce the risk of slow clearing of faults and therefore the exposure of the public and workers to fault energy and earth potential rise hazards.

2.5.2 REDUCED DAMAGE TO NETWORK ASSETS

Rapid and reliable clearing of faults will reduce the fault energy to which the network is exposed with reduced cumulative thermal and mechanical wear and damage to the equipment carrying the fault current. This in particular will result in reduced stress on power transformers supplying the fault current and also reduce the likelihood of bonds being burnt off in the overhead distribution network.

2.5.3 INCREASED PERFORMANCE

Numerical relays provide flexibility, accuracy and performance as well as adding additional functionality and the ability for substantially faster electrical fault clearance times by taking advantage of:

- Multiple programmable characteristic curve shapes;
- A more flexible time shift multiplier;
- A more accurate characteristic (e.g. trip, overshoot and reset times) resulting in the potential for a reduction in coordination margins;
- The ability to use high speed or instantaneous protection at higher fault levels and the ability to change this characteristic by SCADA remote control depending on the circumstances (e.g. during high risk works such as switching and live line work).

2.5.4 INCREASED FUNCTIONALITY

Fault information and response

Immediate remote indication of fault type and fault current which can be provided by numerical relays will enhance critical operational decisions. For example, knowledge of the fault level can assist in determining where on the network the fault is likely to be, leading to faster restoration of supply.

Condition based maintenance

Fault level data transmitted to SCADA presents opportunities to improve condition based maintenance practices. For example, circuit breaker maintenance can be scheduled based on actual wear and tear based on accurate knowledge of actual fault levels experienced by the circuit breaker and by knowing which phases were involved in each fault, compared to the existing practice which assumes a maximum fault level and all three phases exposed for each fault operation.

Forensic analysis of network incidents

Detailed fault records from numerical protection relays connected to the SCADA system assists with the investigation of fault incidents, providing a better understanding of the events and the performance of the network during incidents. This leads to more efficient remedial action resulting in enhanced safety and reliability of the network at lower cost.

3.0 PROPOSED REPLACEMENT PROGRAM

3.1 SCOPE OF WORKS

The proposed replacement works include:

- Replace single relays with new duplicate relays;
- Like for like replacement of all other relays with new numerical relays;
- Wiring and marshalling replacement works, including the wiring of additional circuits to trip coils, circuit breaker failure circuits etc. to connect the new relays to the existing protection and control systems and SCADA systems;
- Modification of protection panels to accommodate the new relays;
- Replacement of associated ancillary relays such as multi-trip and supervision relays, where required.

Furthermore, the extent of renewal of each system should be considered as part of the detailed design process to determine the most cost effective approach that will result in a safe and reliable protection scheme. Consideration should be given to:

- The condition of the existing panel, panel hardware, associated relays, and wiring;
- The level of risk and compliance with standards and regulations, for example the level of redundancy of the system;
- Safety in design considerations such as the safety of exposed live conductors both on the front and the rear of the panel.
- Ergonomics for activities throughout the life cycle of the system (e.g. commissioning, maintenance, operation, de-commissioning).
- Standardisation, ergonomics and familiarity with the layout to minimise the risk of future errors which will impact on network reliability and safety throughout the life cycle of the system (e.g. commissioning, maintenance, operation, de-commissioning).
- Factors such as the scale of the project, economies of scale and the cost difference between the various options.

Based on the above, the works may be extended to renewal of:

- Associated relays on the same panel or bay;
- The hardware on the effected panel or bay, including links, fuses, panel indications etc.
- Wiring and marshalling replacement, including the wiring of additional circuits to trip coils, circuit breaker failure circuits etc;
- Complete panel replacement;
- Associated relays on other panels and bays.

The works at each site should also be coordinated with the Stage 1 works where practicable for efficiency of delivery.

3.2 RELAYS TO REPLACE

It is proposed that 271 relays will be replaced. Table 1 below shows the summary of these relays and the associated costs.

TABLE 1 – RELAY REPLACEMENTS

Relay type	Scheme	Number of relays	Estimated cost ($)
Electromechanical	11kV Frame Leakage	8	210,000
	33kV/66kV Feeder	23	761,000
	33kV Busbar	66	2,025,000
	33kV Frame Leakage	19	480,000

Relay type	Scheme	Number of relays	Estimated cost ($)
	132kV Busbar	4	180,000
	Transformer	71	1,230,000
Electromechanical total		**191**	**4,886,000**
Electronic	11kV Feeder	3	64,000
	11kV Busbar	3	75,000
	11kV Frame Leakage	5	109,000
	Transformer	25	445,000
Electronic total		**36**	**693,000**
Numerical	11kV Feeder	1	32,000
	11kV Busbar	1	181,000
	33kV/66kV Feeder	2	14,000
	33kV Busbar	2	130,000
	Transformer	38	244,000
Numerical total		**44**	**601,000**
Grand Total		**271**	**6,180,000**

Refer to the SAN attached as Appendix A for a list of all relays to be replaced under this program in priority order with the estimated cost of each scheme. The SAN also indicates where there is opportunity to align with the stage 1 works which are documented in PD T-1729. Note that typical current replacement relays for each protection scheme in this business case are shown. The exact model of the replacement relay will be selected during the design phase of each part of the project.

3.3 RELAY REPLACEMENTS OVERLAPPING WITH MAJOR PROJECTS

3.3.1 MARAYONG ZONE SUBSTATION

This program includes the replacement of 16 protection relays at Marayong Zone Substation. A business case is currently being developed for the re-development of Marayong Zone Substation under project TS146 which includes the replacement of all of the protection systems in the substation. Therefore the relay replacement works at Marayong ZS in this program PS008 should be scheduled towards the end of the program and may need to be removed from the program pending the outcome of the TS146 project approval process.

3.3.2 HORSLEY PARK, NORTH ROCKS AND KELLYVILLE ZONE SUBSTATIONS

This program includes the replacement of the 33kV frame leakage and transformer protection relays at Horsley Park, North Rocks and Kellyville zone substations and a 33kV feeder protection relay at North Rocks ZS. A business case is currently being developed to replace the 11kV switchboards in their entirety at these three substations and whilst these works are not likely to include the replacement of the protection relays included in this program PS008, there may be opportunity to coordinate the works at each site for delivery efficiency.

3.4 REPLACEMENT PROGRAM DETAIL AND COST

Table 2 shows the cost of replacing the 271 protection relays as proposed in this business case. Details of the relays are shown in the SAN attached as Appendix A. The relays are located in 37 zone and transmission substations and it is proposed that the works should be carried out over the two year period from 2017/18 – 2018/19. The costs are in real 2017/18 terms and in nominal terms as indicated below.

The total base cost of the works is $6.4 million including an allocation for project definitions and project management works.

TABLE 2 – RELAY REPLACEMENT COSTS

Estimated cost	2017/18	2018/19	Totals
Relay Replacements ($ real FY18)	180,000	6,000,000	**6,180,000**
PD costs	30,000	-	**30,000**
Estimated total cost ($ real FY18)	210,000	6,000,000	**6,210,000**
Estimated total cost ($ nominal)	210,000	6,150,000	**6,360,000**
Project costs ($M) (to nearest $0.1M)	**0.2**	**6.2**	**6.4**

3.5 CONTINGENCY

A contingency amount of $0.5 million (representing 8% of the estimated project base cost) is proposed to allow for unforeseen cost increases due to the works being conducted in aged protection panels in aged substations. These risks are shown in Table 3 below.

TABLE 3 - CONTINGENCY PROVISIONS

Item	Amount ($M)
Addition costs associated with working in panels which contain asbestos and or removal of the asbestos.	0.3
Additional wiring and panel works required due to wiring and or panels being in inadequate condition.	0.2
Total	**0.5**

3.6 PROJECT FUNDING

This project falls within SARP program PS008 – *Substation protection relay refurbishment*. The program summary in the Portfolio Investment Plan (PIP) v8.3 is shown in Table 4 and reflects the risk level and priority of the program.

TABLE 4 – PIP SUMMARY

PIP element	PIP rating
Project ID	PS008
Principal driver	Renewal
Weighted ranking	3,600
Percentage	53.12%

The PIPv8.3 includes an allocation of $4.1 million over the two year period of 2017/18 - 2018/19 for PS008 which included a gradual ramp-up to an annual expenditure level of around

$3 million. This business case, based on the SAN, provides for a more rapid ramping up of expenditure to address imminent renewal needs in line with the AER approved expenditure levels and therefore there is a shortfall in the PIP allocation across FY18 and FY19. However, delivery of the program may follow a different pattern which will be addressed through the Gate 3 change control process as required. Further, adequate provisions for the expenditure forecast for FY19 will be made in the next revision of the PIP.

A nominal split of the expenditure over the two years, including contingency and the allocations currently made for this program in the PIP, the costs associated with the earlier stages of the program and the AER approved funding provision is shown in Table 5 below. The costs for the previous approvals are from the 31 July 2017 Project Management forecast.

TABLE 5 – PROJECT EXPENDITURE SPREAD ($ NOMINAL)

Estimated cost ($M)	2017/18	2018/19	Totals
AER Approval (for PS008)	6.5	6.6	**13.1**
PIP 8.3 provision	1.3	2.8	**4.1**
Project PS008 previous approvals	2.9	3.8	**6.7**
Available PIP8.3 funding	0	0	**0**
Available AER Approved funding	3.6	2.8	**6.4**
This project PS008 stage 2 - base costs	0.2	6.2	**6.4**
Contingency		0.5	**0.5**
Total project cost ($)			**6.9**

4.0 RECOMMENDATIONS

It is recommended that:

- A capital expenditure of $6.4 million to replace 271 protection relays at 37 transmission and zone substations throughout the network during 2017/18 – 2018/19 as detailed in this business case be approved;
- A contingency sum of $0.5 million representing approximately 8% of the estimated cost of the project to cover unforseen events.

The project estimate, including the base costs and the contingency sum, totals $6.9 million.

5.0 APPENDICES

APPENDIX A – Statement of Asset Need and Cost Estimates

APPENDIX A - STATEMENT OF ASSET NEED AND COST ESTIMATES

Memorandum

To	Network Investment Planning Manager	File no	PS008.19.02
From	Protection Engineer	Date	28/07/2017
Subject	**SARP PS008 Protection Relay Renewal:** • Indicative long term protection relay renewal spend requirements FY20-29 • Statement of Asset Need FY18-19 (increase in funding to the existing program)		
Copies	Manager Asset Strategy & Planning		

Background

A large number of protection relay assets have exceeded their technical and financial life expectancy. Additionally, there is a large population of electronic and microprocessor relays which will approach end of life over the coming two regulatory periods.

The protection relay asset renewal approach and spend levels in both prior and current years does not address the ageing population and is insufficient to prevent increasing levels or risk.

The forecast and internally approved spend levels also fall far short of the levels approved by the AER for this regulatory period.

The purpose of this memo is:

- to recommend sustainable and manageable long term relay renewal spend levels to support the development of our future Asset Management Plans and AER determination submission for FY20-24, and

- to act as a statement of asset need for an increase in funding to the protection relay renewal program (PS008) in FY18-19 in order to partially make up for the shortfall between currently approved and sustainable/AER approved spend levels in this regulatory period.

Long term renewal need

The Company has identified the range of expected end-of-life wear out for protection relays as outlined in the table below.

Relay type	End-of-life (years)		
	Early	Mid	Late
Electromechanical	30	45	50
Static/Electronic	20	25	30
Microprocessor/Multifunction	10	20	25

Based on the above life expectancies and excluding the renewal works planned to be conducted under PS012 (distribution feeder modernisation/safety improvements), the long term renewal requirement for the best estimate of life expectancy (the mid-life expectancy as given in the table above) is $62.8m, or $6.3m per annum over the next two regulatory periods (FY20-29).

Renewal cost over 10 years (FY20-29)	Renewal cost p.a. (average per annum in present cost terms)
$62.8m	**$6.3m**

It is recommended that a sustainable long term relay renewal spend level be set based on replacement at the typical or mid-life expectancy age. This approach requires a consistent planned spend level of $6.3m per annum in present cost terms over the next 2 regulatory periods to be spread across PS008 (planned renewal) and PS011 (reactive renewal).

Additional proposed works in FY18-19

The existing approval for PS008 in the two year period FY18-19 allows for a total of $5.8m nominal ($2.9m p.a.) for relay replacement. This compares to an AER approved spend level over the same period of $13m nominal ($6.5m p.a.), and a long term sustainable recommended spend level of $6.3m p.a.

The existing approved funding addresses high risk scenarios only, such as relays with high failure rates, very low quantities, applications where there is an absence of redundancy, and other high consequence applications. This largely reactive approach does little to address the ageing population overall and is not considered to be sustainable in addressing risk longer term, nor is it compatible with stable and deliverable levels of renewal. As such a program of additional works totalling $6.2m across FY18 and FY19 has been developed.

The new additions to the program have been detailed in Appendix C along with the primary basis for replacement which includes the consideration of risk overall by considering age, failure rate, redundancy, criticality, etc.

It is recommended that the funding for PS008 FY18-19 be increased by $6.2m (from $5.8m to $12m) in order to partially make up for the shortfall between currently approved and long term sustainable and AER approved renewal spend levels.

Recommendations

It is recommended that:

- Long term protection relay asset renewal spend levels are planned based on renewal at relay mid-life expectancy age. Over the next two regulatory periods (2019-29), this corresponds to a total spend level of $62.8m, or $6.3m (in present cost terms) to be spread across PS008 (planned renewal) and PS011 (reactive renewal).

- A business case be developed for approval to spend $6.2m plus $0.5m (8%) in contingency in addition to existing approval (PS 008 PD T-1729) over FY18-19 to replace the 271 protection relays at 37 sites (as identified in Appendix C).

Prepared by

28/7/17.

Harshul Dalal
Protection Engineer

Reviewed by:

28/07/17

Matthew Browne
Protection Manager

Endorsed by

31/7/17

Peter West
Substation Design Manager

Endorsed by

31.7.17

Danny Asvestas
Manager Asset Standards & Design

Appendices:

A: Age based relay renewal expenditure tables
B: Relay failure rates
C: Proposed additions to the FY18-19 relay renewal list

Appendix A – Age based protection relay replacement spend levels for FY 2020-2029

Indicative spend levels over the two next regulatory periods based on the different end-of-life ranges identified in the table above are shown in the tables below:

Regulatory Period	Relay Type			Total
	Electromechanical	Static/Electronic	Microprocessor/ Multifunction	
FY20-24	$7.6m	$3.6m	$51.5m	**$62.7m**
FY25-29	$0.22m	$5.1m	$12.8m	**$18.2m**
Total	**$7.8m**	**$8.7m**	**$64.4m**	**$80.9m**

Table 1 - Indicative Spend based on "Early" End-Of-Life Asset Renewal

Regulatory Period	Relay Type			Total
	Electromechanical	Static/Electronic	Microprocessor/ Multifunction	
FY20-24	$4.8m	$1.6m	$14.8m	**$21.2m**
FY25-29	$2.9m	$2.1m	$36.6m	**$41.6m**
Total	**$7.7m**	**$3.7m**	**$62.7m**	**$62.8m**

Table 2 - Indicative Spend based on "Mid" End-Of-Life Asset Renewal

Regulatory Period	Relay Type			Total
	Electromechanical	Static/Electronic	Microprocessor/ Multifunction	
FY20-24	$1.3m	$0.12m	$0.48m	**$1.9m**
FY25-29	$4.0m	$1.9m	$18.8m	**$24.6m**
Total	**$5.3m**	**$2.0m**	**$19.3m**	**$26.5m**

Table 3 - Indicative Spend based on "Late" End-Of-Life Asset Renewal

Appendix B – Relay failure rates (rates >0.5% p.a.)

Relay Model	Failed to Operate Alarmed (per annum)	Mis-operation (per annum)	Failed to Operate Non-alarmed (per annum)	Total (per annum)	Population
SR750	12.41%	0.00%	15.86%	28.28%	16
P121	8.33%	0.00%	3.33%	11.67%	12
KCGU140	0.00%	0.00%	6.67%	6.67%	0
7SA610	5.00%	0.00%	0.00%	5.00%	4
D60	5.00%	0.00%	0.00%	5.00%	4
QUADRAMHO	0.00%	0.00%	4.00%	4.00%	4
ICP-640	4.00%	0.00%	0.00%	4.00%	5
OSM15	4.00%	0.00%	0.00%	4.00%	5
SR745	1.98%	0.40%	1.58%	3.96%	101
P141	2.50%	0.00%	1.25%	3.75%	16
SR760	1.67%	0.00%	1.67%	3.33%	36
SEL-487V	2.86%	0.00%	0.00%	2.86%	7
KCEG140	2.50%	0.00%	0.00%	2.50%	7
KCGG140	0.00%	0.00%	2.22%	2.22%	4
FV2	0.00%	0.00%	2.13%	2.13%	75
CMU*	0.00%	0.25%	1.75%	2.00%	13
SEL-311C	0.95%	0.00%	0.95%	1.90%	20
KCEG142	0.95%	0.00%	0.95%	1.90%	21
BE1-CDS240	0.63%	0.71%	0.54%	1.88%	224
CAPM5	1.25%	0.63%	0.00%	1.88%	28
P445	1.79%	0.00%	0.00%	1.79%	54
P543	1.65%	0.00%	0.09%	1.73%	231
KBCH120	1.67%	0.00%	0.00%	1.67%	12
IEE786	0.00%	1.67%	0.00%	1.67%	12
P633	1.67%	0.00%	0.00%	1.67%	12
RXKL1	0.00%	0.00%	1.43%	1.43%	8
7SA510/7SA511	1.43%	0.00%	0.00%	1.43%	10
P632	1.43%	0.00%	0.00%	1.43%	42
2C138	0.04%	0.02%	1.33%	1.39%	727
HOA4	0.00%	0.00%	1.33%	1.33%	15
ST2	0.00%	0.00%	1.33%	1.33%	15
SPAJ140C	0.71%	0.00%	0.57%	1.28%	113
L90	0.89%	0.00%	0.18%	1.07%	112
2H33	0.00%	0.00%	0.95%	0.95%	21
CDD	0.00%	0.00%	0.93%	0.93%	105
SEL-2505	0.74%	0.00%	0.00%	0.74%	54
MCGG11	0.36%	0.00%	0.36%	0.71%	17
P922	0.24%	0.00%	0.48%	0.71%	84
OC48	0.00%	0.00%	0.70%	0.70%	52
KCGG142	0.23%	0.23%	0.23%	0.70%	33
P541	0.32%	0.32%	0.00%	0.63%	63
TDS	0.00%	0.00%	0.63%	0.63%	93
CAG34	0.00%	0.00%	0.60%	0.60%	64
B90	0.59%	0.00%	0.00%	0.59%	34
D30	0.57%	0.00%	0.00%	0.57%	35
CAG32	0.00%	0.19%	0.38%	0.57%	106
SEL-311B	0.30%	0.00%	0.20%	0.51%	187

Appendix C – Proposed additions to the FY18-19 relay renewal list (in priority order)

Substation	Protection Scheme	Relay to be replaced/removed	Age (at 2019)	Basis for replacement	Works	Estimate Cost	Priority	Region
KEMBLA GRANGE	11kV Feeder CB 25452	SR760	19	Failure Rate - S760	Replace in this program with duplicate protection - IEC 61850 - align with PS008 PD T-1729	$32,000	1	Southern
KEMBLA GRANGE	33kV BBP	2T103	19		Remove in this program - align with PS008 PD T-1729	$0	1	Southern
KEMBLA GRANGE	Transformer #1	KCGG142	19	Failure Rate - KCGG142	Replace in this program - IEC 61850 - align with PS008 PD T-1729	$10,000	1	Southern
KEMBLA GRANGE	Transformer #1	SR745	19	Failure Rate - SR745	Replace in this program - IEC 61850 - align with PS008 PD T-1729	$25,000	1	Southern
KEMBLA GRANGE	Transformer #1	SR760	15	Failure Rate - SR760	Replace in this program - IEC 61850 - align with PS008 PD T-1729	$15,000	1	Southern
KEMBLA GRANGE	Transformer #2	SR745	15	Failure Rate - SR745	Replace in this program - IEC 61850 - align with PS008 PD T-1729	$25,000	1	Southern
KEMBLA GRANGE	Transformer #2	SR760	15	Failure Rate - SR745 and SR760	Replace in this program - IEC 61850 - align with PS008 PD T-1729	$10,000	1	Southern
KEMBLA GRANGE	Transformer #2 LV OC/EF	SR760	15	Failure Rate - SR760	Replace in this program - IEC 61850 - align with PS008 PD T-1729	$15,000	1	Southern
KINGSWOOD	33kV Feeder 457	CDD21	48	Corroded terminals	Replace in this program - align with PS008 PD T-1729	$36,000	1	Northern
KINGSWOOD	33kV Feeder 464 (#1 PROT)	SEL-311B	12	Corroded terminals	Replace in this program - align with PS008 PD T-1729	$30,000	1	Northern

Substation	Protection Scheme	Relay to be replaced/removed	Age (at 2019)	Basis for replacement	Works	Estimate Cost	Priority	Region
KINGSWOOD	33kV Feeder 464 (#2 PROT)	BE1-1051	12	Corroded terminals	Replace in this program - align with PS008 PD T-1729	$30,000	1	Northern
KINGSWOOD	33kV Frame Leakage	CAG32	48	Failure Rate - CAG	Replace in this program - align with PS008 PD T-1729	$45,000	1	Northern
KINGSWOOD	33kV Frame Leakage Check Relay	CAG32	48	Failure Rate - CAG	Remove in this program - align with PS008 PD T-1729	$0	1	Northern
KINGSWOOD	Transformer #1	CDG31	36	Corroded terminals	Replace in this program - align with PS008 PD T-1729	$20,000	1	Northern
KINGSWOOD	Transformer #1	DDT	36	Corroded terminals	Replace in this program - align with PS008 PD T-1729	$25,000	1	Northern
KINGSWOOD	Transformer #1	MVTT14	31	Corroded terminals	Remove in this program - align with PS008 PD T-1729	$5,000	1	Northern
KINGSWOOD	Transformer #2	CDG31	48	Corroded terminals	Replace in this program - align with PS008 PD T-1729	$20,000	1	Northern
KINGSWOOD	Transformer #2	DDT	48	Corroded terminals	Replace in this program - align with PS008 PD T-1729	$25,000	1	Northern
KINGSWOOD	Transformer #3	CDG31	48	Corroded terminals	Replace in this program - align with PS008 PD T-1729	$20,000	1	Northern
KINGSWOOD	Transformer #3	DDT	48	Corroded terminals	Replace in this program - align with PS008 PD T-1729	$25,000	1	Northern
NARELLAN	11kV BBP Bus Section 2-3	P141	18	Failure Rate - P141	Replace in this program - align with PS008 PD T-1729	$25,000	2	Central
NARELLAN	TRANSFORMER #2	KBCH120	18	Failure Rate - KBCH120	Replace in this program - align with PS008 PD T-1729	$25,000	2	Central

Substation	Protection Scheme	Relay to be replaced/removed	Age (at 2019)	Basis for replacement	Works	Estimate Cost	Priority	Region
NARELLAN	TRANSFORMER #2	P123	18	Failure Rate - KBCH120	Replace in this program - align with PS008 PD T-1729	$10,000	2	Central
NARELLAN	TRANSFORMER #2	P141	18	Failure Rate - P141	Replace in this program - align with PS008 PD T-1729	$15,000	2	Central
NARELLAN	TRANSFORMER #3	KBCH120	18	Failure Rate - KBCH120	Replace in this program - align with PS008 PD T-1729	$25,000	2	Central
NARELLAN	TRANSFORMER #3	P123	18	Failure Rate - KBCH120	Replace in this program - align with PS008 PD T-1729	$15,000	2	Central
NARELLAN	TRANSFORMER #3	P141	18	Failure Rate - P141	Replace in this program - align with PS008 PD T-1729	$10,000	2	Central
SPRINGWOOD	Transformer #1(#1Prot)	KCEG140	22	Failure Rate - KCEG140	Replace in this program - align with PS008 PD T-1729	$15,000	2	Northern
SPRINGWOOD	Transformer #2(#1Prot)	KCEG140	22	Failure Rate - KCEG140	Replace in this program - align with PS008 PD T-1729	$15,000	2	Northern
SPRINGWOOD	Transformer #3 SPRINGWOOD ZONE SUB	MBCH12	22	Failure Rate - KCGG140 & SPAJ140 & Close to end of life	Replace in this program - align with PS008 PD T-1729	$7,000	2	Northern
SPRINGWOOD	Transformer #4 SPRINGWOOD ZONE SUB	MBCH12	22	Failure Rate - KCGG140 & SPAJ140 & Close to end of life	Replace in this program - align with PS008 PD T-1729	$7,000	2	Northern
BAULKHAM HILLS TS	33kV BBP Sect 1(#1 PR)	FV2	55	Failure Rate - FV2	Replace in this program	$45,000	3	Northern
BAULKHAM HILLS TS	33kV BBP Sect 1(#1 PR)	TDS	55	Failure Rate - TDS	Replace in this program	$5,000	3	Northern
BAULKHAM HILLS TS	33kV BBP Sect 1(#2 PR)	FV2	55	Failure Rate - FV2	Replace in this program	$45,000	3	Northern

Substation	Protection Scheme	Relay to be replaced/removed	Age (at 2019)	Basis for replacement	Works	Estimate Cost	Priority	Region
BAULKHAM HILLS TS	33kV BBP Sect 1(#2 PR)	TDS	55	Failure Rate - TDS	Replace in this program	$5,000	3	Northern
BAULKHAM HILLS TS	33kV FDR 484 (#2 PR)	CDG31	51	End of Life	Replace in this program	$30,000	3	Northern
BAULKHAM HILLS TS	33kV Pri BBP Sect 2	FV2	55	Failure Rate - FV2	Replace in this program	$45,000	3	Northern
BAULKHAM HILLS TS	33kV Pri BBP Sect 2	TDS	55	Failure Rate - TDS	Replace in this program	$5,000	3	Northern
BAULKHAM HILLS TS	33kV Pri BBP Sect 3	FV2	55	Failure Rate - FV2	Replace in this program	$45,000	3	Northern
BAULKHAM HILLS TS	33kV Pri BBP Sect 3	TDS	55	Failure Rate - TDS	Replace in this program	$5,000	3	Northern
BAULKHAM HILLS TS	33kV Pri BBP Sect 4	FV2	49	Failure Rate - FV2	Replace in this program	$45,000	3	Northern
BAULKHAM HILLS TS	33kV Pri BBP Sect 4	TDS	49	Failure Rate - TDS	Replace in this program	$5,000	3	Northern
BAULKHAM HILLS TS	33kV Sec BBP Sect 2	FV2	55	Failure Rate - FV2	Replace in this program	$45,000	3	Northern
BAULKHAM HILLS TS	33kV Sec BBP Sect 2	TDS	55	Failure Rate - TDS	Replace in this program	$5,000	3	Northern
BAULKHAM HILLS TS	33kV Sec BBP Sect 3	FV2	55	Failure Rate - FV2	Replace in this program	$45,000	3	Northern
BAULKHAM HILLS TS	33kV Sec BBP Sect 3	TDS	55	Failure Rate - TDS	Replace in this program	$5,000	3	Northern
BAULKHAM HILLS TS	33kV Sec BBP Sect 4	FV2	49	Failure Rate - FV2	Replace in this program	$45,000	3	Northern
BAULKHAM HILLS TS	33kV Sec BBP Sect 4	TDS	49	Failure Rate - TDS	Replace in this program	$5,000	3	Northern
MOSS VALE	33kV Feeder 7903	CDD21	52	Failure Rate - CDD - Single Protection	Replace in this program with duplicate protection	$36,000	3	Central
MOSS VALE	33kV Feeder 7904	CDD21	52	Failure Rate - CDD - Single Protection	Replace in this program with duplicate protection	$36,000	3	Central
MOSS VALE	33kV Feeder 7908	CDG61	52	End of Life	Replace in this program	$36,000	3	Central
MOSS VALE	Transformer #1	CDG11	52	Failure Rate - SR745	Replace in this program	$35,000	3	Central

Substation	Protection Scheme	Relay to be replaced/removed	Age (at 2019)	Basis for replacement	Works	Estimate Cost	Priority	Region
MOSS VALE	Transformer #1	CDG31	52	Failure Rate - SR745	Replace in this program	$10,000	3	Central
MOSS VALE	Transformer #1	SR745	19	Failure Rate - SR745	Replace in this program	$25,000	3	Central
MOSS VALE	Transformer #2	CDG11	52	Failure Rate - SR745	Replace in this program	$35,000	3	Central
MOSS VALE	Transformer #2	CDG31	52	Failure Rate - SR745	Replace in this program	$10,000	3	Central
MOSS VALE	Transformer #2	SR745	19	Failure Rate - SR745	Replace in this program	$25,000	3	Central
SEVEN HILLS	33kV Feeder 470	CDD	51	Failure Rate - CDD	Replace in this program	$30,000	3	Northern
SEVEN HILLS	33kV Feeder 475	CDD	50	Failure Rate - CDD	Replace in this program	$30,000	3	Northern
SEVEN HILLS	33kV Feeder 479	CDD	47	Failure Rate - CDD	Replace in this program	$30,000	3	Northern
SEVEN HILLS	33kV Frame Leakage	CAG	57	Failure Rate - CAG	Replace in this program	$35,000	3	Northern
SEVEN HILLS	Transformer #1	CDG31	57	End of Life	Replace in this program	$10,000	3	Northern
SEVEN HILLS	Transformer #1	DDT	57	End of Life	Replace in this program	$25,000	3	Northern
SEVEN HILLS	Transformer #2	CDG31	57	End of Life	Replace in this program	$10,000	3	Northern
SEVEN HILLS	Transformer #2	DDT	57	End of Life	Replace in this program	$25,000	3	Northern
SEVEN HILLS	Transformer #2	MVTT14	39	End of Life	Replace in this program	$5,000	3	Northern
SEVEN HILLS	Transformer #3	CDG31	50	End of Life	Replace in this program	$10,000	3	Northern
SEVEN HILLS	Transformer #3	DDT	44	End of Life	Replace in this program	$25,000	3	Northern
WEST CASTLE HILL	11kV Bus-sec 27192	KCEG142	18	Failure Rate - KCEG142	Replace in this program - align with PS008 PD T-1729	$25,000	3	Northern
WEST CASTLE HILL	11kV FDR BS3 - 27186	KCGG142	20	Failure Rate - KCGG142	Replace in this program with duplicate protection - align with PS012 works	$32,000	3	Northern
WEST CASTLE HILL	11kV Low Impedance BBP	MBCZ10	20	Low Population and Links Design Issue	Replace in this program - align with PS008 PD T-1729	$181,000	3	Northern
WEST CASTLE HILL	TX #1 11kV CB 27185	KCEG142	18	Failure Rate - KCEG142	Replace in this program - align with PS008 PD T-1729	$25,000	3	Northern

Substation	Protection Scheme	Relay to be replaced/removed	Age (at 2019)	Basis for replacement	Works	Estimate Cost	Priority	Region
WEST CASTLE HILL	TX #2 11kV CB 27196	KCEG142	18	Failure Rate - KCEG142	Replace in this program - align with PS008 PD T-1729	$25,000	3	Northern
BLACKTOWN TS	33KV FEEDER 427 (#1 PR)	HO4	25	High Failure Rates - HOXXX	Replace in this program - align with PS008 PD T-1729	$45,000	4	Central
CAMELLIA TS	33kV Feeder 403 (#2 PROT)	CDG31	54	End of Life	Replace in this program	$35,000	4	Northern
CAMELLIA TS	33kV Feeder 404 (#2 PROT)	CDG31	54	End of Life	Replace in this program	$35,000	4	Northern
CAMELLIA TS	33kV Pri BBP Sect 1	FV2	54	Failure Rate - FV2	Replace in this program	$45,000	4	Northern
CAMELLIA TS	33kV Pri BBP Sect 2	FV2	54	Failure Rate - FV2	Replace in this program	$45,000	4	Northern
CAMELLIA TS	33kV Pri BBP Sect 3	FV2	54	Failure Rate - FV2	Replace in this program	$45,000	4	Northern
CAMELLIA TS	33kV Pri BBP Sect 4	FV2	54	Failure Rate - FV2	Replace in this program	$45,000	4	Northern
CAMELLIA TS	33kV Sec BBP Sect 1	FV2	54	Failure Rate - FV2	Replace in this program	$45,000	4	Northern
CAMELLIA TS	33kV Sec BBP Sect 2	FV2	54	Failure Rate - FV2	Replace in this program	$45,000	4	Northern
CAMELLIA TS	33kV Sec BBP Sect 3	FV2	54	Failure Rate - FV2	Replace in this program	$45,000	4	Northern
CAMELLIA TS	33kV Sec BBP Sect 4	FV2	54	Failure Rate - FV2	Replace in this program	$45,000	4	Northern
MARAYONG	33kV Feeder 445	SR760	17	Failure Rate - SR760	Replace in this program - to be reviewed based on outcome of TS146 NIO	$35,000	4	Northern
MARAYONG	33kV Feeder 470	CDD21	52	Failure Rate - CDD	Replace in this program - to be reviewed based on outcome of TS146 NIO	$35,000	4	Northern
MARAYONG	33kV Feeder 473	CDD21	57	Failure Rate - CDD	Replace in this program - to be reviewed based on outcome of TS146 NIO	$35,000	4	Northern
MARAYONG	33kV Frame Leakage	CAG32	46	Failure Rate - CAG	Replace in this program - to be reviewed based on outcome of TS146 NIO	$35,000	4	Northern

Substation	Protection Scheme	Relay to be replaced/removed	Age (at 2019)	Basis for replacement	Works	Estimate Cost	Priority	Region
MARAYONG	33kV Frame Leakage Check Relay	MCAG32	15	Failure Rate - CAG	Replace in this program - to be reviewed based on outcome of TS146 NIO	$5,000	4	Northern
MARAYONG	Transformer #1	2T101	39		Remove in this program - to be reviewed based on outcome of TS146 NIO	$0	4	Northern
MARAYONG	Transformer #1	CDG31	57	End of Life	Replace in this program - to be reviewed based on outcome of TS146 NIO	$25,000	4	Northern
MARAYONG	Transformer #1	SR750	18	High Failure Rate - SR750	Replace in this program - to be reviewed based on outcome of TS146 NIO	$15,000	4	Northern
MARAYONG	Transformer #2	2T101	39		Remove in this program - to be reviewed based on outcome of TS146 NIO	$0	4	Northern
MARAYONG	Transformer #2	CDG31	58	End of Life	Replace in this program - to be reviewed based on outcome of TS146 NIO	$10,000	4	Northern
MARAYONG	Transformer #2	DDT32	53	End of Life	Replace in this program - to be reviewed based on outcome of TS146 NIO	$25,000	4	Northern
MARAYONG	Transformer #2	SR750	18	High Failure Rate - SR750	Replace in this program - to be reviewed based on outcome of TS146 NIO	$15,000	4	Northern
MARAYONG	Transformer #3	2T101	39		Remove in this program - to be reviewed based on outcome of TS146 NIO	$0	4	Northern
MARAYONG	Transformer #3	CDG31	47	End of Life	Replace in this program - to be reviewed based on outcome of TS146 NIO	$10,000	4	Northern
MARAYONG	Transformer #3	DDT	52	End of Life	Replace in this program - to be reviewed based on outcome of TS146 NIO	$25,000	4	Northern
MARAYONG	Transformer #3	SR750	18	High Failure Rate - SR750	Replace in this program - to be reviewed based on outcome of TS146 NIO	$15,000	4	Northern

Substation	Protection Scheme	Relay to be replaced/removed	Age (at 2019)	Basis for replacement	Works	Estimate Cost	Priority	Region
NEWTON	33kV Feeder 450	SR760	17	Failure Rate - S760	Replace in this program - align with PS008 PD T-1729	$7,000	4	Northern
SOUTH PROSPECT	33kV Feeder 427	HO4	25	High Failure Rates - HOXXX	Replace in this program - align with PS008 PD T-1729	$45,000	4	Central
SOUTH PROSPECT	33kV Feeder 427	MCGG52	25	High Failure Rates - HOXXX	Replace in this program - align with PS008 PD T-1729	$7,000	4	Central
SOUTH PROSPECT	33kV Feeder 431	MCGG52	25	High Failure Rates - HOXXX	Replace in this program - align with PS008 PD T-1729	$7,000	4	Central
ANZAC VILLAGE	11kV Bus Section 2-3 CB	KCEG142	19	End of Life	Replace in this program - align with PS008 PD T-1729	$25,000	5	Central
ANZAC VILLAGE	Transformer #2	KBCH120	25	Failure Rate - KBCH120	Replace in this program - align with PS008 PD T-1729	$25,000	5	Central
ANZAC VILLAGE	Transformer #2	KCGG142	25	Failure Rate KCGG142	Replace in this program - align with PS008 PD T-1729	$10,000	5	Central
ANZAC VILLAGE	Transformer #3	KBCH120	25	Failure Rate - KBCH120	Replace in this program - align with PS008 PD T-1729	$25,000	5	Central
ANZAC VILLAGE	Transformer #3	KCGG142	25	Failure Rate KCGG142	Replace in this program - align with PS008 PD T-1729	$10,000	5	Central
FAIRFAX LANE TS	33kV BBP Sect 1 Primary	FV2	53	Failure Rate - FV2	Replace in this program - align with PS008 PD T-1729	$45,000	5	Central
FAIRFAX LANE TS	33kV BBP Sect 1 Primary	TDS	53	Failure Rate - TDS	Replace in this program - align with PS008 PD T-1729	$5,000	5	Central
FAIRFAX LANE TS	33kV BBP Sect 1 Secondary	FV2	53	Failure Rate - FV2	Replace in this program - align with PS008 PD T-1729	$45,000	5	Central

Substation	Protection Scheme	Relay to be replaced/removed	Age (at 2019)	Basis for replacement	Works	Estimate Cost	Priority	Region
FAIRFAX LANE TS	33kV BBP Sect 1 Secondary	TDS	53	Failure Rate - TDS	Replace in this program - align with PS008 PD T-1729	$5,000	5	Central
FAIRFAX LANE TS	33kV BBP Sect 2 Primary	FAC34	41	End of Life	Replace in this program - align with PS008 PD T-1729	$45,000	5	Central
FAIRFAX LANE TS	33kV BBP Sect 2 Primary	TDS	41	Failure Rate - TDS	Replace in this program - align with PS008 PD T-1729	$5,000	5	Central
FAIRFAX LANE TS	33kV BBP Sect 2 Secondary	FAC34	41	End of Life	Replace in this program - align with PS008 PD T-1729	$45,000	5	Central
FAIRFAX LANE TS	33kV BBP Sect 2 Secondary	TDS	41	Failure Rate - TDS	Replace in this program - align with PS008 PD T-1729	$5,000	5	Central
MOUNT TERRY TS	132kV BBP Section X-Y (#1 PROT)	FV2	51	Failure Rate - FV2	Replace in this program	$45,000	5	Southern
MOUNT TERRY TS	132kV BBP Section X-Y (#2 PROT)	FV2	51	Failure Rate - FV2	Replace in this program	$45,000	5	Southern
MOUNT TERRY TS	132kV BBP Section Z (#1 PROT)	FV2	51	Failure Rate - FV2	Replace in this program	$45,000	5	Southern
MOUNT TERRY TS	132kV BBP Section Z (#2 PROT)	FV2	51	Failure Rate - FV2	Replace in this program	$45,000	5	Southern
MOUNT TERRY TS	33kV BBP Sect 1 (#1 PROT)	FV2	51	Failure Rate - FV2	Replace in this program	$45,000	5	Southern
MOUNT TERRY TS	33kV BBP Sect 1 (#2 PROT)	FV2	51	Failure Rate - FV2	Replace in this program	$45,000	5	Southern
MOUNT TERRY TS	33kV BBP Sect 2 (#1 PROT)	FV2	51	Failure Rate - FV2	Replace in this program	$45,000	5	Southern
MOUNT TERRY TS	33kV BBP Sect 2 (#2 PROT)	FV2	51	Failure Rate - FV2	Replace in this program	$45,000	5	Southern
MOUNT TERRY TS	33kV BBP Sect 3 (#1 PROT)	FV2	51	Failure Rate - FV2	Replace in this program	$45,000	5	Southern
MOUNT TERRY TS	33kV BBP Sect 3 (#2 PROT)	FV2	51	Failure Rate - FV2	Replace in this program	$45,000	5	Southern

Substation	Protection Scheme	Relay to be replaced/removed	Age (at 2019)	Basis for replacement	Works	Estimate Cost	Priority	Region
MT DRUITT TS	33kV Primary BBP Sect 1	FV2	49	Failure Rate - FV2	Replace in this program	$45,000	6	Northern
MT DRUITT TS	33kV Primary BBP Sect 1	TDS	49	Failure Rate - TDS	Replace in this program	$5,000	6	Northern
MT DRUITT TS	33kV Primary BBP Sect 2	FV2	49	Failure Rate - FV2	Replace in this program	$45,000	6	Northern
MT DRUITT TS	33kV Primary BBP Sect 2	TDS	49	Failure Rate - TDS	Replace in this program	$5,000	6	Northern
MT DRUITT TS	33kV Primary BBP Sect 3	FV2	49	Failure Rate - FV2	Replace in this program	$45,000	6	Northern
MT DRUITT TS	33kV Primary BBP Sect 3	TDS	49	Failure Rate - TDS	Replace in this program	$5,000	6	Northern
MT DRUITT TS	33kV Primary BBP Sect 4	FV2	49	Failure Rate - FV2	Replace in this program	$45,000	6	Northern
MT DRUITT TS	33kV Primary BBP Sect 4	TDS	49	Failure Rate - TDS	Replace in this program	$5,000	6	Northern
MT DRUITT TS	33kV Secondary BBP Sect 1	FV2	49	Failure Rate - FV2	Replace in this program	$45,000	6	Northern
MT DRUITT TS	33kV Secondary BBP Sect 1	TDS	49	Failure Rate - TDS	Replace in this program	$5,000	6	Northern
MT DRUITT TS	33kV Secondary BBP Sect 2	FV2	49	Failure Rate - FV2	Replace in this program	$45,000	6	Northern
MT DRUITT TS	33kV Secondary BBP Sect 2	TDS	49	Failure Rate - TDS	Replace in this program	$5,000	6	Northern
MT DRUITT TS	33kV Secondary BBP Sect 3	FV2	49	Failure Rate - FV2	Replace in this program	$45,000	6	Northern
MT DRUITT TS	33kV Secondary BBP Sect 3	TDS	49	Failure Rate - TDS	Replace in this program	$5,000	6	Northern
MT DRUITT TS	33kV Secondary BBP Sect 4	FV2	49	Failure Rate - FV2	Replace in this program	$45,000	6	Northern
MT DRUITT TS	33kV Secondary BBP Sect 4	TDS	49	Failure Rate - TDS	Replace in this program	$5,000	6	Northern
OUTER HARBOUR TS	33kV BBP Sect 1 (#1 PROT)	FV2	50	Failure Rate - FV2	Replace in this program	$45,000	6	Southern
OUTER HARBOUR TS	33kV BBP Sect 1 (#2 PROT)	FV2	50	Failure Rate - FV2	Replace in this program	$45,000	6	Southern

Substation	Protection Scheme	Relay to be replaced/removed	Age (at 2019)	Basis for replacement	Works	Estimate Cost	Priority	Region
OUTER HARBOUR TS	33kV BBP Sect 2 (#1 PROT)	FV2	50	Failure Rate - FV2	Replace in this program	$45,000	6	Southern
OUTER HARBOUR TS	33kV BBP Sect 2 (#2 PROT)	FV2	50	Failure Rate - FV2	Replace in this program	$45,000	6	Southern
YENNORA	33kV Frame Leakage	CAG12	55	Failure Rate - CAG	Replace in this program - align with PS011 33kV feeder works	$35,000	6	Central
YENNORA	33kV Frame Leakage Check Relay	CAG12	55	Failure Rate - CAG	Replace in this program - align with PS011 33kV feeder works	$5,000	6	Central
DAPTO	11kV Frame Leakage	CAG32	57	Failure Rate - CAG	Replace in this program	$35,000	7	Southern
KIAMA	11kV Frame Leakage	CAG12	55	Failure Rate - CAG	Replace in this program - align with PS008 PD T-1729	$35,000	7	Southern
KIAMA	33kV BBP	CAG34	55	Failure Rate - CAG	Replace in this program - align with PS008 PD T-1729	$45,000	7	Southern
KIAMA	Transformer #1	CO6	55	End of Life	Replace in this program - align with PS008 PD T-1729	$12,500	7	Southern
KIAMA	Transformer #1	CO9	55	End of Life	Replace in this program - align with PS008 PD T-1729	$12,500	7	Southern
KIAMA	Transformer #2	CO6	55	End of Life	Replace in this program - align with PS008 PD T-1729	$12,500	7	Southern
KIAMA	Transformer #2	CO9	55	End of Life	Replace in this program - align with PS008 PD T-1729	$12,500	7	Southern
KIAMA	Transformer #3 EF	CDG21	40	End of Life	Replace in this program - align with PS008 PD T-1729	$12,500	7	Southern
KIAMA	Transformer #3 OC	CDG21	40	End of Life	Replace in this program - align with PS008 PD T-1729	$12,500	7	Southern

Substation	Protection Scheme	Relay to be replaced/removed	Age (at 2019)	Basis for replacement	Works	Estimate Cost	Priority	Region
MOOREBANK	33kV Frame Leakage	CAG	55	Failure Rate - CAG	Replace in this program	$30,000	7	Central
MOOREBANK	33kV Frame Leakage Check Relay	CAG	55	Failure Rate - CAG	Remove in this program	$5,000	7	Central
WEST WOLLONGONG	11kV Frame Leakage	CAG12	57	Failure Rate - CAG	Replace in this program	$35,000	7	Southern
WEST WOLLONGONG	33kV BBP	CAG34	55	Failure Rate - CAG	Replace in this program	$45,000	7	Southern
ALBION PARK	11kV Frame Leakage	CAG	51	Failure Rate - CAG	Replace in this program - align with PS008 PD T-1729	$30,000	9	Southern
ALBION PARK	11kV Frame Leakage Check Relay	CAG	51	Failure Rate - CAG	Replace in this program - align with PS008 PD T-1729	$5,000	9	Southern
ALBION PARK	33kV BBP	FV2	51	Failure Rate - FV2	Replace in this program - align with PS008 PD T-1729	$30,000	9	Southern
ALBION PARK	33kV BBP	TDS	51	Failure Rate - TDS	Replace in this program - align with PS008 PD T-1729	$5,000	9	Southern
ALBION PARK	33kV Feeder 7123	CDG11	51	End of Life	Replace in this program - align with PS008 PD T-1729	$35,000	9	Southern
ALBION PARK	33kV Feeder 7158	CDG21	51	End of Life	Replace in this program - align with PS008 PD T-1729	$35,000	9	Southern
CARRAMAR	33kV Frame Leakage	CAG12	40	Failure Rate - CAG	Replace in this program	$35,000	10	Central
CARRAMAR	33kV LI BBP	MBCZ10	23	Low Population	Replace in this program	$130,000	10	Central
PLUMPTON	33kV Frame Leakage	CAG32	51	Failure Rates - CAG	Replace in this program - align with PS008 PD T-1729	$35,000	11	Northern
PLUMPTON	Transformer #2	CDG31	49	End of Life	Replace in this program - align with PS008 PD T-1729	$10,000	11	Northern

Substation	Protection Scheme	Relay to be replaced/removed	Age (at 2019)	Basis for replacement	Works	Estimate Cost	Priority	Region
PLUMPTON	Transformer #2	DDT	50	End of Life	Replace in this program - align with PS008 PD T-1729	$25,000	11	Northern
PLUMPTON	Transformer #3	CDG31	56	End of Life	Replace in this program - align with PS008 PD T-1729	$10,000	11	Northern
PLUMPTON	Transformer #3	DDT	49	End of Life	Replace in this program - align with PS008 PD T-1729	$25,000	11	Northern
PORTLAND	Transformer #1	CDG31	35	End of Life	Replace in this program	$15,000	11	Northern
PORTLAND	Transformer #1	CDG31	35	End of Life	Replace in this program	$10,000	11	Northern
PORTLAND	Transformer #1	DDT	52	End of Life	Replace in this program	$25,000	11	Northern
PORTLAND	Transformer #2	2T101	25	End of Life	Replace in this program	$5,000	11	Northern
PORTLAND	Transformer #2	CDG31	37	End of Life	Replace in this program	$15,000	11	Northern
PORTLAND	Transformer #2	CDG31	34	End of Life	Replace in this program	$10,000	11	Northern
PORTLAND	Transformer #2	DDT	52	End of Life	Replace in this program	$25,000	11	Northern
NORTH ROCKS	33kV Feeder 472	CDD21	52	Failure Rate - CDD	Replace in this program	$30,000	12	Northern
NORTH ROCKS	33kV Frame Leakage	CAG32	48	Failure Rate - CAG	Replace in this program	$35,000	12	Northern
NORTH ROCKS	33kV Frame Leakage Check Relay	MCAG32	48	Failure Rate - CAG	Replace in this program	$5,000	12	Northern
NORTH ROCKS	Transformer #1	CDG31	49	End of Life	Replace in this program	$15,000	12	Northern
NORTH ROCKS	Transformer #1	CDG31	48	End of Life	Replace in this program	$10,000	12	Northern
NORTH ROCKS	Transformer #1	DDT32	50	End of Life	Replace in this program	$25,000	12	Northern
NORTH ROCKS	Transformer #1	MVTT14	30		Replace in this program	$0	12	Northern
NORTH ROCKS	Transformer #2	CDG31	50	End of Life	Replace in this program	$10,000	12	Northern
NORTH ROCKS	Transformer #2	CDG31	49	End of Life	Replace in this program	$15,000	12	Northern
NORTH ROCKS	Transformer #2	DDT32	50	End of Life	Replace in this program	$25,000	12	Northern
KELLYVILLE	33kV Frame Leakage	CAG32	50	Failure Rate - CAG	Replace in this program	$35,000	13	Northern
KELLYVILLE	Transformer #2	2T101	28	End of Life	Replace in this program	$5,000	13	Northern
KELLYVILLE	Transformer #2	CDG11	49	End of Life	Replace in this program	$5,000	13	Northern
KELLYVILLE	Transformer #2	CDG31	57	End of Life	Replace in this program	$10,000	13	Northern
KELLYVILLE	Transformer #2	DDT	54	End of Life	Replace in this program	$25,000	13	Northern
KELLYVILLE	Transformer #3	2T101	28	End of Life	Replace in this program	$5,000	13	Northern

Substation	Protection Scheme	Relay to be replaced/removed	Age (at 2019)	Basis for replacement	Works	Estimate Cost	Priority	Region
KELLYVILLE	Transformer #3	CDG11	49	End of Life	Replace in this program	$5,000	13	Northern
KELLYVILLE	Transformer #3	CDG31	57	End of Life	Replace in this program	$10,000	13	Northern
KELLYVILLE	Transformer #3	DDT32	50	End of Life	Replace in this program	$25,000	13	Northern
KELLYVILLE	Transformer #4 & CB 8640	2DCC	26	End of Life	Replace in this program	$10,000	13	Northern
KELLYVILLE	Transformer #4 & CB 8640	2T101	26		Replace in this program	$0	13	Northern
KELLYVILLE	Transformer #4 & CB 8640	MBCH12	26	End of Life	Replace in this program	$20,000	13	Northern
KELLYVILLE	Transformer #5 & CB 8650	2DCC	26	End of Life	Replace in this program	$10,000	13	Northern
KELLYVILLE	Transformer #5 & CB 8650	2T101	26		Replace in this program	$0	13	Northern
KELLYVILLE	Transformer #5 & CB 8650	MBCH12	26	End of Life	Replace in this program	$20,000	13	Northern
HORSLEY PARK	33kV Frame Leakage	CAG32	51	Failure Rate - CAG	Replace in this program - align with PS008 PD T-1729	$35,000	14	Central
HORSLEY PARK	Transformer #2	CDG31	57	End of Life	Replace in this program - align with PS008 PD T-1729	$10,000	14	Central
HORSLEY PARK	Transformer #2	DDT	47	End of Life	Replace in this program - align with PS008 PD T-1729	$25,000	14	Central
HORSLEY PARK	Transformer #2	MVTT14	30		Replace in this program - align with PS008 PD T-1729	$0	14	Central
HORSLEY PARK	Transformer #3	CDG31	57	End of Life	Replace in this program - align with PS008 PD T-1729	$10,000	14	Central
HORSLEY PARK	Transformer #3	DDT	49	End of Life	Replace in this program - align with PS008 PD T-1729	$25,000	14	Central
HORSLEY PARK	Transformer #3	MVTT14	30		Replace in this program - align with PS008 PD T-1729	$0	14	Central

Substation	Protection Scheme	Relay to be replaced/removed	Age (at 2019)	Basis for replacement	Works	Estimate Cost	Priority	Region
QUAKERS HILL	33kV Frame Lakage	CAG	45	Failure Rate - CAG	Replace in this program - align with PS008 PD T-1729	$30,000	15	Northern
QUAKERS HILL	33kV Frame Leakage Check Relay	CAG	45	Failure Rate - CAG	Replace in this program - align with PS008 PD T-1729	$5,000	15	Northern
QUAKERS HILL	Transformer #3	CDG31	45	End of Life	Replace in this program - align with PS008 PD T-1729	$10,000	15	Northern
QUAKERS HILL	Transformer #3	DDT	52	End of Life	Replace in this program - align with PS008 PD T-1729	$25,000	15	Northern
QUAKERS HILL	Transformer #3	MVTT14	38	End of Life	Replace in this program - align with PS008 PD T-1729	$5,000	15	Northern
QUAKERS HILL	Transformer #4	CDG31	45	End of Life	Replace in this program - align with PS008 PD T-1729	$10,000	15	Northern
QUAKERS HILL	Transformer #4	DDT	52	End of Life	Replace in this program - align with PS008 PD T-1729	$25,000	15	Northern
QUAKERS HILL	Transformer #4	MVTT14	38	End of Life	Replace in this program - align with PS008 PD T-1729	$5,000	15	Northern
SOUTH WOLLONGONG	11kV Frame Leakage	CAG	52	Failure Rate - CAG	Replace in this program	$35,000	15	Southern
SOUTH WOLLONGONG	33kV BBP Check Zone	FAC34	52	Failure Rate - CAG	Replace in this program	$15,000	15	Southern
SOUTH WOLLONGONG	33kV BBP Sect A	CAG34	52	Failure Rate - CAG	Replace in this program	$15,000	15	Southern
SOUTH WOLLONGONG	33kV BBP Sect B	CAG34	52	Failure Rate - CAG	Replace in this program	$15,000	15	Southern
UNANDERRA	ZS, 33kV, BBP	FAC	56	End of Life	Replace in this program	$45,000	15	Southern
UNANDERRA	11kV Frame Leakage	CAG32	56	Failure Rate - CAG	Replace in this program	$25,000	15	Southern

Substation	Protection Scheme	Relay to be replaced/removed	Age (at 2019)	Basis for replacement	Works	Estimate Cost	Priority	Region
UNANDERRA	11kV Frame Leakage	CAG32	56	Failure Rate - CAG	Replace in this program	$10,000	15	Southern
HAZELBROOK	11kV Feeder W121	2C138	6		Remove in this program align with PS012 PD T-1733	$0	16	Northern
HAZELBROOK	11kV Feeder W121	MCGG11	31	End of Life	Replace in this program with duplicate protection - align with PS012 PD T-1733	$32,000	16	Northern
HAZELBROOK	Transformer #1	CDG31	31	End of Life	Replace in this program	$10,000	16	Northern
HAZELBROOK	Transformer #1	CDG31	31	End of Life	Replace in this program	$15,000	16	Northern
HAZELBROOK	Transformer #1	MBCH12	31	End of Life	Replace in this program	$25,000	16	Northern
HAZELBROOK	Transformer #1	MCSU	31		Remove in this program	$0	16	Northern
HAZELBROOK	Transformer #1	MVTT14	31		Replace in this program	$0	16	Northern
HAZELBROOK	Transformer #2	CDG31	31	End of Life	Replace in this program	$10,000	16	Northern
HAZELBROOK	Transformer #2	CDG31	31	End of Life	Replace in this program	$15,000	16	Northern
HAZELBROOK	Transformer #2	MBCH12	31	End of Life	Replace in this program	$25,000	16	Northern
HAZELBROOK	Transformer #2	MCSU	19		Remove in this program	$0	16	Northern
HAZELBROOK	Transformer #2	MVTT14	31		Replace in this program	$0	16	Northern
JASPER RD	33kV Feeder 469	CDD21	51	Failure Rate - CDD	Replace in this program	$7,000	17	Northern
JASPER RD	33kV Feeder 469	HO2	50	Failure Rate - HOXXX & End of Life	Replace in this program with line differential using existing fibre links	$50,000	17	Northern
JASPER RD	33kV Feeder 469 Backup OC	CDD21	44	Failure Rate - CDD	Remove in this program	$0	17	Northern
JASPER RD	33kV Feeder 471	CDD21	57	Failure Rate - CDD	Replace in this program	$30,000	17	Northern
JASPER RD	33kV Feeder 484	CDD21	57	Failure Rate - CDD	Replace in this program	$30,000	17	Northern
JASPER RD	33kV Frame Leakage	CAG32	51	Failure Rate - CAG	Replace in this program	$35,000	17	Northern
JASPER RD	Transformer #1	2T101	39		Remove in this program	$0	17	Northern
JASPER RD	Transformer #1	CDG31	51	End of Life	Replace in this program	$25,000	17	Northern
JASPER RD	Transformer #2	2T101	39		Remove in this program	$0	17	Northern
JASPER RD	Transformer #2	CDG31	51	End of Life	Replace in this program	$25,000	17	Northern
JASPER RD	Transformer #3	2T101	39		Remove in this program	$0	17	Northern
JASPER RD	Transformer #3	CDG31	44	End of Life	Replace in this program	$25,000	17	Northern

Substation	Protection Scheme	Relay to be replaced/removed	Age (at 2019)	Basis for replacement	Works	Estimate Cost	Priority	Region
KELLYVILLE	33kV Feeder 469	MHOB04	16	Failure Rate - HOXXX	Replace in this program with line differential using existing fibre links	$50,000	17	Northern
KELLYVILLE	33kV Feeder 469	SR760	16	Failure Rate - SR760	Replace in this program	$7,000	17	Northern
GREYSTANES	33kV Frame Leakage	CAG	53	Failure Rate - CAG	Replace in this program	$35,000	18	Northern
GREYSTANES	Transformer #1	2T101	39	End of Life	Remove in this program	$5,000	18	Northern
GREYSTANES	Transformer #1	CDG31	51	End of Life	Replace in this program	$10,000	18	Northern
GREYSTANES	Transformer #1	DDT	45	End of Life	Replace in this program	$25,000	18	Northern
GREYSTANES	Transformer #2	2T101	39	End of Life	Remove in this program	$5,000	18	Northern
GREYSTANES	Transformer #2	CDG31	51	End of Life	Replace in this program	$10,000	18	Northern
GREYSTANES	Transformer #2	DDT	45	End of Life	Replace in this program	$25,000	18	Northern
CASTLE HILL	Transformer #1	2T104	27		Remove in this program - align with PS008 PD T-1729	$0	19	Northern
CASTLE HILL	Transformer #1	CO6	58	End of Life	Replace in this program - align with PS008 PD T-1729	$15,000	19	Northern
CASTLE HILL	Transformer #1	MCGG22	27	Failure Rate - MCGG	Replace in this program - align with PS008 PD T-1729	$25,000	19	Northern
CASTLE HILL	Transformer #2	2T104	27		Remove in this program - align with PS008 PD T-1729	$0	19	Northern
CASTLE HILL	Transformer #2	CO6	54	End of Life	Replace in this program - align with PS008 PD T-1729	$15,000	19	Northern
CASTLE HILL	Transformer #2	MCGG22	27	Failure Rate - MCGG	Replace in this program - align with PS008 PD T-1729	$25,000	19	Northern
CASTLE HILL	Transformer #3	2T104	27		Remove in this program - align with PS008 PD T-1729	$0	19	Northern

Substation	Protection Scheme	Relay to be replaced/removed	Age (at 2019)	Basis for replacement	Works	Estimate Cost	Priority	Region
CASTLE HILL	Transformer #3	CO6	58	End of Life	Replace in this program - align with PS008 PD T-1729	$15,000	19	Northern
CASTLE HILL	Transformer #3	MCGG22	27	Failure Rate - MCGG	Replace in this program - align with PS008 PD T-1729	$25,000	19	Northern
					Total	**$6,180,000**		