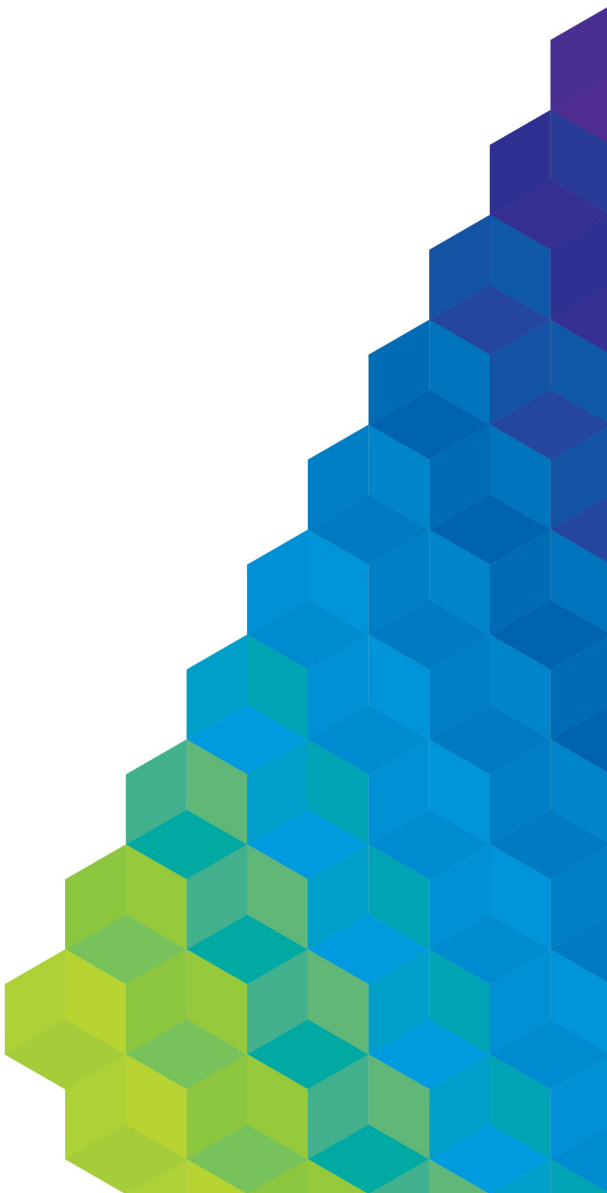
Operational Requirements

Contingent Project Application



1 PURPOSE AND BACKGOUND

1.1 Purpose

The purpose of this supporting document is to explain the changes and new activities necessitated by the Rapid Earth Fault Current Limiter (REFCL) installation program. These activities will lead to increased operational expenditure as explained in this document.

1.2 Background

The 2009 Victorian Bushfire Royal Commission made several recommendations with respect to fires initiated by distribution electricity networks. Subsequently, the Victorian Government established the Powerline Bushfire Safety Program to research the optimal way to deploy REFCLs for bushfire prevention. This research led the Government to introduce the Electricity Safety (Bushfire Mitigation) Amendment Regulations 2016, which set new performance standards that can only be met by AusNet Services installing REFCL technology in 22 specified zone substations.

The introduction of this technology imposes new operational requirements and activities that must be undertaken in order to safely and effectively operate the electricity distribution network. This document explains that the largest component of the required increase in operating expenditure (approximately 28%) is driven by the annual testing requirements mandated in the regulations.

2 Incremental operations and maintenance activities

The REFCL devices to be installed during the program fundamentally change the way the network operates in regard to how it is earthed. With a REFCL device, the interaction between the network and the earth during fault conditions is manipulated to significantly limit the likelihood of starting a fire.

A description of the key operating activities is provided below.

2.1 Annual testing

Annual tests take the form of Primary Earth Fault Testing and Insulation Testing at each site. The first of these tests will be performed as part of the capital installation project for that site. As such, the costs of those initial tests are included in capital expenditure relating to the installation of the REFCL.

Each test is described in more detail below. These are in addition to the testing that AusNet Services currently performs on non-REFCL portions of the network.

2.1.1 Primary earth fault tests

Annual testing before each declared bushfire season is required by the Electricity Safety (Bushfire Mitigation) Regulations to “ensure that its [AusNet Services’] supply network can operate to meet the required capacity in relation to each polyphase electric line.”[1]

[1] Electricity Safety (Bushfire Mitigation) Regulations 2013 (amended 2016), Section 7(1)(hb)

This testing will take the form of primary earth fault testing on at least one feeder per REFCL at each site by triggering an actual fault onto the system and testing the performance and operation of the REFCL. Primary earth fault testing – sometimes referred to as primary fault-throw testing – involves closing a switch onto a phase of the electricity system to induce an actual fault on the network. The operation of the associated REFCL is then assessed and measured to ensure it is operating correctly. Introduction of this fault will not generally lead to supply interruptions for customers.

2.1.2 Insulation tests

It is prudent to perform insulation testing on all feeders once a year to determine the condition of the overall system[2]. Insulation testing, or 'hardening' testing, allows for the detection of equipment that is overly stressed and is likely to fail during REFCL operation so that it can be replaced. Conversely, it allows 'borderline' equipment to be kept in service for longer if no weaknesses are detected. This approach reduces the likelihood of 'cross country' faults and keeps replacement costs as low as possible through only targeting equipment that has a higher risk of failure. A ‘cross country’ fault is where otherwise unrelated equipment can fail after an initial phase-ground fault on the network. After such a fault, the other phases of the network experience a voltage rise and if equipment on those phases cannot withstand the elevated voltage, that equipment may fail.

2.2 Network balancing activities

The introduction of the REFCL devices changes the networks from a solidly (sometimes called effectively) earthed system to a resonant earth system. Resonant earth systems are much more sensitive to imbalances in capacitance between phases of the power system. If the imbalance is too great, the REFCL may fail to operate correctly. Therefore, the following new balancing activities are required:

- Capacitance forecasting;
- Initiation of remedial works; and
- Day to day capacitance testing.

These activities are described in further detail in the sections that follow.

2.2.1 Capacitance forecasting

To ensure design is adequate, annual capacitance forecasting will need to be undertaken to ensure any changes to the system do not negatively impact the operation of the REFCL. These changes may be brought about by proposed projects, or may have been introduced by the completion of other projects.

This task will be undertaken concurrently with annual load forecasting studies and would review all proposed network changes for the upcoming year to determine where imbalances might be introduced.

2.2.2 Initiation of remedial works

If significant imbalances are identified as having been introduced, or likely to be introduced by project work, remedial projects will need to be initiated to restore balance to affected parts of the

[2] Marxsen Tony. (2014). *REFCL Trial: Ignition Tests*. Marxsen Consulting Pty Ltd. p.89

network. The remedial works will typically need to be scoped, estimated and then justified through a business case before any works will take place.

2.2.3 Day-to-day capacitance analysis

On a day-to-day basis, additional planning and analysis will need to be undertaken for planned and unplanned outages. Based on experience from Woori Yallock, it is expected that there will be approximately three planned outages per week per zone substation that include interaction with REFCL devices. When plant is taken out of service, the configuration of the network changes and hence the balancing of capacitance across the phases may change as well. Care must be taken so that the network is not placed in a configuration that unbalances the capacitance to the degree that the REFCL device will fail to operate correctly.

The analysis will be required:

- When network applicants apply for outages to plant and equipment;
- Before and during switching activities to provide such access; and
- Before and during restoration of such plant and equipment.

Analysis of network capacitances is required frequently because the state and configuration of the network changes continually and any upcoming reconfiguration needs to take into account the state of the network immediately before those switching activities occur. For example, planning for jobs takes place three or more weeks in advance, and will be based on the 'normal' configuration of the network. When switching occurs on the day, the network may actually be in a different configuration. Similarly, the network may change configuration between switching equipment out of service and when that equipment is to be restored.

In addition to the three activities described above, there will also be a requirement for AusNet Services to provide technical support for HV customers.

2.3 Fault response

It is expected that the time spent on fault response and analysis will increase due to the complexities of the resonant earthing network. Local expertise has generally been concerned with analysis of solidly earthed systems. With a move to resonant systems, engineers will be learning on the job as new fault data is obtained over time.

This data will need to be analysed and understood in order to ensure that fault response is improved or the system design is able to be changed to prevent the occurrence of a similar fault in the future.

2.4 Establish documentation

In order to operate and maintain the REFCL devices over time, documentation will need to be created for other areas of the business, such as the Customer & Energy Operation Team (CEOT) and maintenance teams. This documentation includes:

- Operating instructions;
- Maintenance instructions; and
- Testing requirements.

Operating instructions are used to describe how the REFCL will be operated in the system, covering switching instructions and considerations.

Maintenance instructions explain how each component of the REFCL system is to be maintained and the frequency of that maintenance.

Lastly, testing documentation outlines AusNet Services' policy regarding annual testing as described in Section 2.1.

2.5 Equipment maintenance

After the REFCL devices are installed, they will be subject to routine maintenance similar to any other plant and equipment in the zone substation. A small incremental operating expenditure allowance has been included in AusNet Services' contingent project application to cover the cost of performing routine maintenance of the assets that have been installed in the zone substations.

2.6 Line equipment purchases

The introduction of REFCL devices imposes higher voltage conditions on existing installed lines infrastructure. Where in the past equipment had to be designed to withstand voltages up to 12.7 kV, REFCL networks need to be able to withstand nominal voltages in the order of 22 kV + 10%.

Some of the equipment that AusNet Services uses for operating and maintaining the network is not rated to handle these higher voltages. Such equipment includes:

- Mid-span isolator units;
- Rigid hoppers;
- Insulated hard covers; and
- Line cut-out tools.

Many of these items will be capitalised, but insulated hard covers do not meet the unit cost requirements for capitalisation and therefore their cost has been included in our forecast of incremental operating expenditure for the REFCL contingent project.

2.7 Alternative technologies and vendors

Currently, there is only one supplier of REFCL equipment, representing only one technology that is potentially available. This sole supplier model introduces risk that any type failures inherent in the design could cripple the fleet of installed REFCL devices. There are also risks in a single suppliers' ability to deliver large quantities of product in the timeframe required.

To minimise risk it is prudent to engage with other suppliers and work with them to develop a comparable and compliant product. To that end, AusNet Services proposes to commit resources to engage with alternative suppliers to explore alternatives technologies that could be used to achieve the 'required capacity' in an efficient manner.

2.8 Training and change management

2.8.1 Technical training and familiarisation

As REFCL devices are introduced to new areas, there will be a need to provide training and familiarisation of the new devices to the operations, planning and maintenance crews in those areas. The training and familiarisation will be conducted by subject matter experts who have gained significant knowledge and experience during the installation of the Worri Yallock REFCL.

2.8.2 Change management

The introduction of REFCL devices will involve a significant element of change management. There will be technical, processual and operational changes to embed across most areas of the business. A consultant has been engaged to specifically assist with the REFCL change management plan and implementation.

2.9 Update policy documents and reporting

To reflect the changes introduced by REFCL devices, AusNet Services will need to update key business documentation including the Asset Management Strategy and Policy documents.

Monthly reporting will be required to meet ESV's requirements. There is some level of reporting that already exists, but ultimately these reports will need to be modified in a once-off, upfront effort and subsequently administered on an ongoing basis.

3 Summary of costs

An overall summary of the forecast operational expenditure required to operate and maintain installed REFCL devices between 2017 and 2020 is provided below. These estimates cover Tranche 1 installations only.

The costs are presented in real $2016.

A breakdown of the assumptions for each activity is provided in Section 4.

	Expenditure Year			
Activity	**2017**	**2018**	**2019**	**2020**
Incremental operations and maintenance				
Annual testing				
Primary earth fault tests	$17,399	$69,596	$191,389	$208,788
Insulation tests	$10,343	$41,372	$113,773	$124,116
Network balancing activities				
Capacitance forecasting	$11,400	$14,250	$17,100	$22,800
Initiation of remedial works	$5,700	$17,100	$45,600	$51,300
Day-to-day capacitance analysis	$19,305	$57,915	$154,440	$173,745
Fault response				
Fault response & analysis	$27,000	$72,000	$81,000	$81,000
Establish documentation				
Operating, maintenance and testing instructions	$30,000	$0	$0	$4,500
Equipment maintenance				
Routine maintenance of zone substation assets	$0	$9,462	$37,848	$37,848
Line equipment purchases				
Purchase of hard covers	$71,980	$62,776	$0	$0
Alternative technologies and vendors				
Liaison with suppliers	$123,750	$247,500	$123,750	$0
Training and change management				
Technical training and familiarisation	$107,813	$107,813	$0	$0
Change management	$148,200	$0	$0	$0
Update policy documents & reporting				
Update policy & strategy documents	$22,800	$0	$0	$0
Modified ESV reporting	$11,172	$5,472	$5,472	$5,472
Annual Totals	**$606,862**	**$705,256**	**$770,372**	**$709,569**
Grand Total				**$2,792,058**

Table 1: Operational Expenditure cost summary for Tranche 1 REFCL installations

4 Explanation of incremental operating expenditure forecasts

The costs presented in the previous section have been built up from cost estimates of each activity. General assumptions are listed below.

4.1 Installation timetable and labour rates

4.1.1 REFCL installation timetable

Below are the proposed sites and installed REFCL population scheduled between 2017 and 2020. These numbers relate to Tranche 1 installations only.

Year (cumulative number of REFCLs)	2017 (4)	2018 (11)	2019 (12)	2020 (12)
Sites	Woori Yallock (2) Rubicon A (1) Barnawatha (1)	Seymour (2) Wangaratta (2) Wonthaggi (1) Kinglake (1) Myrtleford (1)	Kilmore South (1)	*Nil*

Table 2: REFCL Installations for Tranche 1

This proposed schedule is used to directly estimate costs that are incurred on a per-site or per-REFCL basis each year.

4.1.2 Labour rates

Assumptions:

- Labour rates are consistent with those used in the EDPR submission.
- Operational staff (Testers, Controllers, Operators, Applicants, etc) work an 8.33 hour day
- Operational staff labour rate is $125 per hour
- Engineering and other office based staff work a 7.5 hour day
- Engineering staff labour rate is $152 per hour

4.2 Activities

4.2.1 Annual testing

Primary earth fault tests

Assumptions:

- The initial primary earth fault tests at a site will be conducted as part of the installation project and capitalised. These costs are not presented in this paper.
- Subsequent annual primary earth fault tests are part of the operational expenditure and included in this analysis.

- Based on experience from Woori Yallock, testing will take one full day.
- These tests are required per REFCL device.

The resource and cost estimates for the annual primary earth fault tests of each REFCL device are provided below:

Job type - ANNUAL Primary Earth Fault Testing	Units (p.d, p.unit)	Unit cost	Total (excl mat)
Outage planning	7.5	$125.00	$937.50
2 Testers at site	16.7	$125.00	$2,082.50
Field crew, including Traffic control	1.0	$7,989.00	$7,989.00
1 Operator at site	7.5	$125.00	$937.50
Test crew, including test equipment	1.0	$4,000.00	$4,000.00
1 Controller	10.0	$125.00	$1,250.00
Reporting of results (Engineer)	7.5	$152.00	$1,140.00
Total			***$17,399.00***

Table 3: Cost estimate for primary earth fault testing

In Table 3 above, the test crew is distinct from the onsite testers as they are the 'initiators' of the fault out in the field and they take any field-based test measurements. The field crew are present to fix any issues that may arise from the fault testing.

Insulation testing

Assumptions:

- The initial insulation tests at a site will be conducted as part of the installation project and capitalised. These costs are not presented in this paper.
- Subsequent annual insulation tests are part of the operational expenditure and included in this analysis.
- Based on experience from Woori Yallock, testing will take one full day.
- These tests are required *per station*.

The resource and cost estimates of the annual insulation stress test for each zone substation are provided below:

Job type - ANNUAL Stress Testing	Units (p.d, p.unit)	Unit cost	Total (excl mat)
Outage planning	7.5	$125.00	$937.50
2 Testers onsite	15.0	$125.00	$1,875.00
1 Fault crews per day	1.0	$3,168.00	$3,168.00
1 Operator at site	1.0	$125.00	$125.00
Traffic Control	1.0	$1,744.00	$1,744.00
1 Controller	10.0	$125.00	$1,250.00
Fault response	0.2	$5,467.40	$1,093.48
Customer community resource	1.5	$100.00	$150.00
Total			***$10,342.98***

Table 4: Cost estimate for insulation (stress) testing

4.2.2 Network balancing activities

Capacitance forecasting

Assumptions:

- Forecasting activity takes two weeks full-time initially.
- As more sites/REFCL devices are installed the forecasting activity takes longer, up to four weeks full-time.

Initiation of remedial works

Assumptions:

- Remedial works activities include scope and business case development, review and approval and takes 4 weeks full-time per project.
- There will be one remedial works project for every four zone substations.

Day-to-day capacitance analysis

Assumptions:

- Applications and network switching will require analysis of capacitive balancing.
- An allocation of 20 minutes each has been allowed for making applications for access, switching and restoration.
- The 20 minutes will include analysis of the proposed network configuration after switching has occurred, to determine if the network capacitance can be balanced sufficiently in the proposed configuration.

4.2.3 Fault analysis

Assumptions:

- Based on early experience from Woori Yallock, one fault per REFCL device per month will need detailed analysis.
- The above experience has shown that the detailed analysis takes one full day to complete on average.

4.2.4 Establish documentation

Assumptions:

- Maintenance documentation will be required for routine maintenance of the REFCL and associated equipment. These are referred to as Standard Maintenance Instructions (SMIs).
- Operational documents will be required in the Customer and Energy Operations Team (CEOT). These are essentially instructions for operating/switching the REFCL and associated equipment.
- Each document will take four weeks to prepare, including review and approval
- The bulk of this work will be upfront
- Documents are reviewed every three years thereafter
- Document review takes three days per document, including review and approval

4.2.5 Equipment maintenance

Assumptions:

- Maintenance costs are incurred the year following REFCL installation.
- Maintenance costs are based on a small nominal increase in the average annual maintenance cost per zone substation.
- The nominal increase is proportional to the increase in assets in a typical zone substation.

4.2.6 Line equipment purchases

Assumptions:

- AusNet Services and committed Delivery Partners have a total of 571 hard covers that will need to be replaced during Tranche 1.
- Hard covers cost $236 each, based on current pricing.
- Costs for replacement have been allocated to the year that the relevant depot receives its first REFCL device.
- AusNet Services can either purchase hard covers for committed Delivery Partners directly or have them update their equipment themselves. If the latter option is taken, the Delivery Partners will on cost the purchase price to AusNet Services.
- A committed Delivery Partner is one with whom AusNet Services has a long term service agreement. Intermittent contractors are not included in this assessment.

4.2.7 Alternative technologies and vendors

Assumptions:

- Work will be carried out over two years, beginning mid 2017.
- The resource requirement will be 1.5 Full-Time Equivalent (FTE).

4.2.8 Training and change management

Technical training and familiarisation

Assumptions:

- Employees to be trained include testers, operators, planners, etc.
- Fifteen employees in total will be trained across two main regions.
- The above employees will participate in training for five days.
- Four employees will be used as trainers.
- Trainer involvement will be for ten days – five for each region.

Change management

Assumptions:

- A resource will be employed for change management activities.
- The above resource will be required at 1.0 FTE for six months.

4.2.9 Update policy documents and ESV reporting

Assumptions:

- Updating of all related documentation takes four weeks, including review and approval.
- Modification of existing reports takes one week to develop, test and implement.
- Reporting is conducted monthly.
- Report preparation takes three hours per month.

5 Concluding Comments

Tranche 1 involves the installation of twelve REFCL devices at nine zone substations in AusNet Services' distribution network. Delivering Tranche 1 will require incremental operating expenditure as described in this paper. Our incremental operating expenditure is $606.9k in 2017, increasing to $709.6k by 2020 in relation to the REFCL devices installed in Tranche 1 of the program.

The largest component of expenditure (approximately 28% of the total incremental operating expenditure in 2020) will be for testing, which is required by legislation in accordance with advice from industry experts, so as to ensure that the REFCL devices will operate correctly and will not overly stress the surrounding network to a point where consequential failures may occur.

Secondly, our forecast incremental operating expenditure will support significant engineering activities around the design and operation of the network. This will involve detailed analysis of network capacitances and the effects that augmentation and other projects have on those capacitances. From this activity, remedial works will be planned and implemented to ensure that the REFCL devices can operate to the 'required capacity' reliably and safely.

Furthermore, analysis will be performed when planning and switching the network into new configurations, to again ensure that the REFCL device can operate correctly in the new configuration.

Lastly, the expenditure will support the updating of policy and strategy documents and the creation of operational and maintenance instructions and guidelines. These documents will guide and inform delivery staff to undertake their maintenance and operating activities efficiently, to ensure that the REFCL devices operate optimally and as required.

Wherever possible, estimates have been built from experiential data from similar activities. For example, the experiences of the REFCL installation at Woori Yallock have been drawn upon heavily in determining the frequency of certain activities and the actual incurred costs have been used to further estimate likely expenditure.

The labour rates used are consistent with the EDPR.