Rapid Earth Fault Current Limiter (REFCL) Program

Compatible Equipment – Automatic Circuit Recloser Strategy

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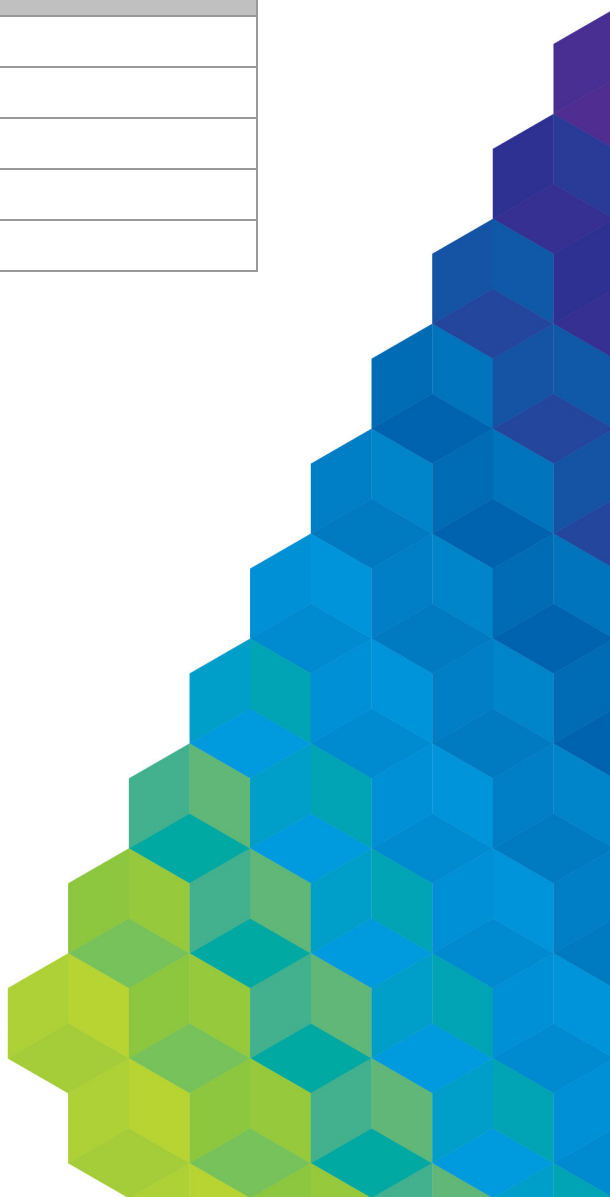

REVISION HISTORY

Issue Number	Date	Description	Author
1	13/03/2017	First Issue	J Bernardo
2	18/04/2018	Second Issue – Revised for Tranche 2	K Soodin

1 PURPOSE AND BACKGOUND

1.1 Purpose

The purpose of this supporting document is to explain AusNet Services' strategy in relation to Automatic Circuit Reclosers (ACRs) operating on 22kV networks affected by the installation of the Rapid Earth Fault Current Limiter (REFCL) installation program.

REFCLs are to be installed on AusNet Services' network in response to new bushfire mitigation regulations. The replacement or upgrade of 22kV ACRs falls within the scope of works that we refer to as 'compatible equipment'. Compatible equipment is one of 5 work streams that comprise the REFCL installation program. As part of the REFCL installation program, the ACR strategy is focused on prudently and efficiently meeting AusNet Services' regulatory obligations.

This category of work involves the planned replacement or upgrade of assets that are known to be non-compatible with the new REFCL technology. Other 'compatible equipment' works include the replacement of line voltage regulators. A separate supporting document is provided in relation to our replacement strategy for those assets.

1.2 Background

AusNet Services' network operates in a unique geographical location, which is exposed to extreme bushfire risk. These conditions warrant significant investment to mitigate the bushfire risk.

The 2009 Victorian Bushfire Royal Commission made several recommendations with respect to fires initiated from 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 Electricity Safety (Bushfire Mitigation) Amendment Regulations 2016.

For AusNet Services, the regulations require each polyphase electric line originating from 22 selected zone substations to comply with mandated voltage reduction performance standards by 1 May 2023. In the timeframes specified in the regulations, the installation of REFCLs is the only feasible technological solution.

The REFCL installation program will be managed in three Tranches. This ACR strategy is expected to remain valid for all 3 Tranches however any changes to the strategy as a result of REFCL Program deployment learnings will be captured as a revision to this document.

ACRs are used throughout our 22kV network to provide protection and isolation of faults. ACRs also have the capability to reclose after interruption of a fault allowing coordination with other field devices (sectionalisers) to minimise the number of impacted customers. The minimisation of customers due to a fault is achieved through a Distributed Automation Feeder (DFA) scheme which facilitates the connection of adjacent feeders or sections to the nearest ACR to the fault.

This response, coordination and management of faults has been designed for low impedance or solidly earthed networks and ensures system reliability is at its optimum. As explained in this strategy document, ACRs on the REFCL protected network (high impedance) including transfer feeders as part of the DFA scheme will require upgrades or replacements.

1.3 Strategy objective

The objective of our ACR strategy is to:

- describe the issues associated with the operation of ACRs on a network utilising REFCLs;
- ensure ACR maloperations do not occur during REFCL operation; and

- demonstrate that the ACR strategy is prudent and efficient.

2 Investment need

The ACRs on our network provide non-directional protection (i.e. they respond to fault current flowing in either direction through the device), which is typical for low impedance or solidly earthed networks. Unfortunately the existing ACR's are not compatible with REFCL technology as earth fault current paths flow differently (towards the zone substation bus) when resonant earthing is employed. Traditional earth fault and sensitive earth fault protection will need to be blocked when the REFCL is in service.

In order to avoid maloperation of ACRs, each ACR is assessed to ensure accurate Voltage Transformers (VTs) and Current Transformers (CTs) are capable of supplying the reference points. This assessment results in a variety of ACR upgrades or replacements depending on the type of ACR installed on the network. Software (firmware) changes to the controller of the ACR will need to be adapted so that earth fault protection algorithms can be automatically coordinated when switching between low impedance or solidly earthed networks and resonant earthed network configurations. These algorithms will address the blocking of earth fault and sensitive earth fault protection as well as through fault detection, whilst ensuring that dangerous network conditions are isolated by correctly disconnecting the faulted zone.

The need to upgrade or replace incompatible equipment, such as ACRs, was addressed in the REFCL trial report:

> *"Some network equipment currently used in Victoria is not compatible with REFCL operation and must be upgraded or replaced with equipment that is compatible.… Incompatible equipment can prevent correct REFCL operation and may produce dangerous network conditions with a REFCL in service."*[1]

The Electricity Safety (Bushfire Mitigation) Amendment Regulations (2016) specify the installation and operation of the voltage reduction required on a polyphase line when a phase-to-ground fault occurs, and the fault current levels that must be achieved. These specifications can only be met where existing ACRs are upgraded or replaced.

The volume of non-compatible ACRs requiring upgrade or replacement in tranche two of the REFCL program varies between zone substations.

3 Options analysis and preferred approach

The installation of REFCLs on the existing network requires the establishment of cost effective methods to upgrade or replace ACRs to achieve compliance with the Regulations. As already noted, this work is essential for REFCL technology to operate safely. i.e. to operate without increasing the likelihood of dangerous network conditions.

The proposed approach to address non-compatible ACRs on REFCL protected feeders involves a combination of:

- In the minority of cases, installation of VTs and CTs to provide references for REFCL compliant protection algorithms;
- In the minority of cases, upgrading existing ACR controller units for new VTs and CTs;
- In all cases, apply firmware upgrades to ACR controller units for REFCL compliant protection algorithms; *and*

[1] Dr Anthony Marxsen, REFLC Trial: Ignition Tests, Marxsen Consulting Pty Ltd, Monday 4 August 2014, page 94.

- In the minority of cases, replacing ACRs with new units where retrofitting any of the above is not possible.

Before determining the preferred approach above (option 1) to ACR modifications, 2 alternative approaches were considered.

- On REFCL protected networks, replace all existing ACRs including control units. This results in a larger number of ACRs to be replaced (Option 2 below).
- On REFCL protected networks, carry out manual suppressions and manual fault isolation only. This results in an unfavourable outcome for customers as it will result in unnecessary disconnection due to an earth fault along with longer outage times due to non-sectionalised fault targets which are used during the fault finding process (Option 3 below).

No other viable options were identified.

A summary of our analysis in relation to each of these options is shown in Table 1.

Table 1: Options evaluated

Option	Advantages	Disadvantages
1. Retrofit ACR hardware and software (where possible) and replace other incompatible ACRs on REFCL networks	Ensures REFCL operating compliance. Reduces volume of work required over Option 2. Ensures cost efficiency. Maintains existing network reliability. Cost estimated at cheaper than option 2 as upgrades are two thirds the price of an ACR replacement	Software development required resulting in increased dependency on manufacturer.
2. Replace all existing ACRs including control units on REFCL networks.	Uniform approach. Improves reliability, as new ACRs are likely to be more reliable than old ACRs. Maintains existing network reliability.	Software development required resulting in increased dependency on manufacturer. Increases volume of work required. Greater cost than Option 1 as ACR replacement are more expense than ACR upgrades
3. Carry out manual suppressions and manual fault isolation only on REFCL protected networks	Reduces volume of work required as no replacements necessary.	Non-compliant to REFCL operation. Increases customer impact as time of outage will be dependent on ability to locate fault manually. Counter to the purpose of the REFCL program as fault may not be correctly identified. Reduces reliability. New approach is time consuming

Option	Advantages	Disadvantages
		and labour intensive requiring controllers to follow manual procedures consequently resulting in a higher cost.

The key risk associated with the upgrade of ACRs is that some may initially be assessed as suitable for upgrade but later be found to be unsuitable. This will lead to the need to replace, rather than upgrade the ACR, leading to increased cost and delays.

A further risk is related to schedule. The timing of the work and ensuring the ACR works are completed will be dependent on the network requirements at the time i.e. maintenance or customer project works may present conflicted access to ACRs being upgraded or replaced. This risk will be mitigated by completing the works prior to summer and co-ordinating the works with other work activities. There is also an increased risk of not having the equipment to upgrade in a timely manner, should the development of protection algorithms not be proven to achieve the targeted detection sensitivity. The impact of delays to the ACR program is on customer experience rather delaying the commissioning of REFCLs. i.e. customers on feeders where ACR's have not been upgraded will experience longer outage times following a fault.

While the preferred option has higher performance risks compared to Option 2, there is a cost saving. Option 1 is the preferred option as it has:

- Lower cost than Option 2; *and*
- Meets the objective of safe compatible operation with REFCL technology.

4 Efficient and prudent program delivery

The following high level delivery plan is to:

1. Assess current installations of ACRs and determine retrofit requirements;
2. Develop hardware and software specifications with ACR manufacturers;
3. Functionally test algorithms at ACR manufacturer premises prior to wide scale deployment;
4. Install and trial ACR upgrades on a REFCL protected network prior to wide scale deployment. Completion of primary earth fault tests required to validate the ACR upgrades
5. Once proven, proceed with ACR deployment.

This sequence of activities ensures that the more expensive activity (replacing/upgrading ACRs) is only undertaken after the technology has been proven to compatible with requirements of a REFCL protected network.

Ensuring delivery efficiency of the above plan relies on integration of compatible equipment works with other works on the network, such as business as usual maintenance, safety programs and other REFCL related line works.

4.1 Risk management

The risks associated with delivery of the program for ACR replacements or upgrades are shown in the table below.

Risk	What could occur	Actions & controls
Interference / clashes with other project(s) and project scope creep.	Delivery delays leading to non-compliance with Bushfire Mitigation Regulations and the approved Bushfire Mitigation Plan. Down time for construction crews	Continual engagement with Network Planning Teams and delivery partners. Network Programs constant review of Portfolio projects. Dedicated Program Sponsor Team established.
Delivery delays in meeting the timetable specified in the regulations.	Delivery delays leading to non-compliance with Bushfire Mitigation Regulations and the approved Bushfire Mitigation Plan. ACR VT and CT upgrades not completed in time. ACR software algorithms not working.	Monthly reporting of the progress of the project from delivery partners through to the Program Team / Steering Committee and Energy Safe Victoria. Regular updates of Asset Management System enabling progress to be tracked real-time. Well planned schedule of works. Early engagement with Control Energy Operations Team (CEOT), delivery partners and field personnel to ensure resourcing availability. Constant engagement with ACR manufacturer. Thorough testing of ACR hardware and software upgrades.
ACRs not available when required for fault isolation.	ACRs out of service due to upgrade or replacement activities. ACRs not able to minimise customers affected due to an outage.	Works to be completed when ACRs are not anticipated to be required. Where ACRs are to be replaced, works to be constructed alongside existing units. Cutover to new unit to be undertaken over a reduced period, decreasing outage time.

4.2 Procurement

Upgraded specification ACRs and control boxes will become standard stock items. These items have been procured utilising AusNet Services' standard procurement and governance processes which include competitive tendering to ensure the cost per unit is efficient.

4.3 Works delivery

As stated above, the volume of non-compatible ACRs requiring upgrade or replacement will vary per zone substation and per Tranche. A summary of the ACR works required for each REFCL installation will be included in the respective zone substation REFCL Planning Report.

The ACR works will be constructed using established external delivery partner relationships and processes.

4.4 Program costs and benchmarking

The ACR Strategy preferred option has been costed in accordance with our standard costing methodology, as detailed in the supporting document: Cost Estimating, program delivery and unit rates.

The costs take into account:

- Site visits;
- Design of ACR replacement or upgrades;
- Bench testing ACR control boxes units;
- Works and network contingency planning and governance activities;
- Construction works;
- Testing, communications and commissioning;
- Project management; and
- Auditing.

A summary of the capital expenditure requirements for each REFCL installation will be included in the respective zone substation REFCL Planning Report.

5 Concluding comments

This document has explained that:

- The proposed scope of ACR upgrade and replacement is the lowest cost option for addressing the specific issues on REFCL protected networks;
- A standard approach to estimating the costs of ACR upgrades or replacements has been used;
- The key assumptions underpinning the forecasts are reasonable;
- We have identified the key risks in relation to ACR modification works and taken appropriate risk mitigation measures; and
- Our projected costs (refer to relevant Planning reports) are consistent with the estimated average unit costs in the RIS.

In addition, it should be noted that our forecast expenditure for REFCL compatible equipment has been subject to our standard business case review and approval processes. This work will also be subject to our project management and governance arrangements.

For these reasons, we regard the forecast expenditure for our compatible equipment approach as prudent and efficient, in accordance with the Rules requirements relating to contingent projects.