Rapid Earth Fault Current Limiter (REFCL) Program

Compatible Equipment – Automatic Circuit Recloser Strategy

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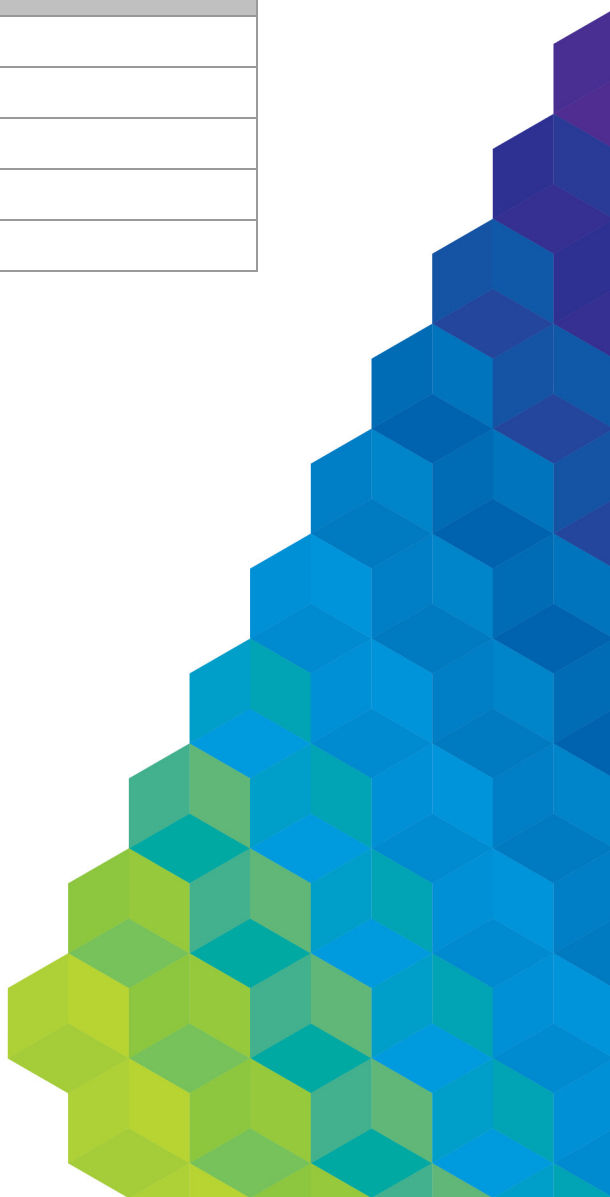

REVISION HISTORY

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1	13/03/2017	First Issue	J Bernardo

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 line voltage regulator strategy is focused on Tranche 1, which will be completed by 30 April 2019. At this stage, it is expected that the strategy will remain valid to Tranches 2 and 3. However, this will be confirmed prior to the commencement of these later Tranches.

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 have been designed for low impedance or solidly earthed networks and ensures system reliability is at its optimum. As explained in this strategy document, 79 ACRs on the REFCL protected network (high impedance) will require upgrades or replacements in Tranche 1.

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, which is typical for low impedance or solidly earthed networks. Unfortunately they are not compatible with REFCL technology as earth fault current paths flow differently (towards the zone substation bus) when resonant earthing is employed, the basis of a REFCL. 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 the 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 one 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 automatic circuit reclosers 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, 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 the risk of unnecessarily disconnection due to an earth fault is increased 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 $4,621k	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 at $4,996k
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 dependant 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 and labour intensive requiring controllers to follow manual procedures consequently

Option	Advantages	Disadvantages
		resulting in a higher cost.

The key risk associated with the upgrade of automatic circuit reclosers is that some ACRs 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.

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.

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 specification with ACR manufacturer;
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 (installing ACRs) is only undertaken after the technology has been proven to comply with the Regulations.

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 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

Automatic circuit reclosers and control boxes to be installed 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 automatic circuit reclosers requiring upgrade or replacement in tranche one of the REFCL program varies between zone substations.

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

Table 4-1: Summary of works required

	Units requiring upgrade	Units requiring replacement
Wonthaggi	1	13
Myrtleford	-	6
Barnawartha	-	1
Kilmore South	4	-
Rubicon A	-	6
Kinglake	-	6
Wangaratta	1	19
Seymour	-	8
Woori Yallock	10	4
Total	**16**	**63**

Source: AusNet Services

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 detailed below in Table 4-2 include:

- 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.

Table 4-2: Summary of capital expenditure requirements

	Upgrades Cost $000s 2016 direct	Replacement Costs $000s 2016 direct
Wonthaggi	40	823
Myrtleford	0	376
Barnawartha	0	64
Kilmore South	160	0
Rubicon A	0	380
Kinglake	0	380
Wangaratta	40	1,202
Seymour	0	506
Woori Yallock	399	253
Total	**639**	**3,988**

Source: AusNet Services

To demonstrate the efficiency and prudency of our proposed expenditure, we must have regard to available benchmark information. We note that the Regulatory Impact Statement (RIS) prepared by ACIL ALLEN for the Victorian Government in 2015 provided the variation in costing for automatic circuit reclosers (referred to as 'Polyphase ACR upgrades').

The RIS estimate forecast[2], 0 - 18 upgrades per zone substation at $70,000 each upgrade. Our average costs per upgrade is $59,000, which is below the RIS estimate. It is noted that Wangaratta has the highest replacement cost, involving 22 ACRs to be replaced or upgraded. This volume of work is higher than estimated in the RIS (which indicated a range of 1 - 18 ACR units per zone substation), but it reflects the network configuration at Wangaratta and the replacement volume is unavoidably high. In summary, the cost comparison provides further assurance that AusNet Services' cost forecasts are prudent and efficient.

It is also important to emphasise that the cost forecasts presented in this contingent project application reflect a detailed scope of work for each zone substation installation in accordance with the AER's 'trigger event' definition. As such, AusNet Services' forecasts are fully substantiated having regard to the actual conditions at each zone substation whereas the RIS estimate adopted a broader estimating approach that was unavoidably less comprehensive.

4.5 Program governance

While the ACR upgrade or replacement program will be managed using the AusNet Services' Portfolio Framework, an overarching REFCL Program Governance Framework has been established in order to provide end-to-end Program oversight and accountability, to identify and manage program level risks.

[2] [2] Regulatory Impact Statement, Bushfire Mitigation Regulations Amendment, ACIL ALLEN Consulting, Table 14, Page 69. It should be noted that the RIS costs are expressed in $2015 while our costs are expressed in $2016. Strictly speaking, for comparison purposes the RIS costs are approximately 1.5 per cent higher than indicated here.

The REFCL Program Governance Framework aligns to AusNet Services' values and commitment to mission zero with:

- Clear accountabilities, reporting and robust risk and issue management;
- Sustainable, long term, reliable, economical and workable whole of life designs;
- Delivery as per agreed timelines without compromising reliability and other service standards;
- Integration where possible with the rest of the AusNet Services work program;
- Compliance with required obligations;
- Strong relationships with all stakeholders in order to successfully manage change;
- Development of internal capability in order to facilitate the transition to business as usual; and
- Use of business as usual processes and resources where possible.

5 Concluding comments

This supporting 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 the 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.