Rapid Earth Fault Current Limiter (REFCL) Program

Compatible Equipment – Voltage Regulator Strategy

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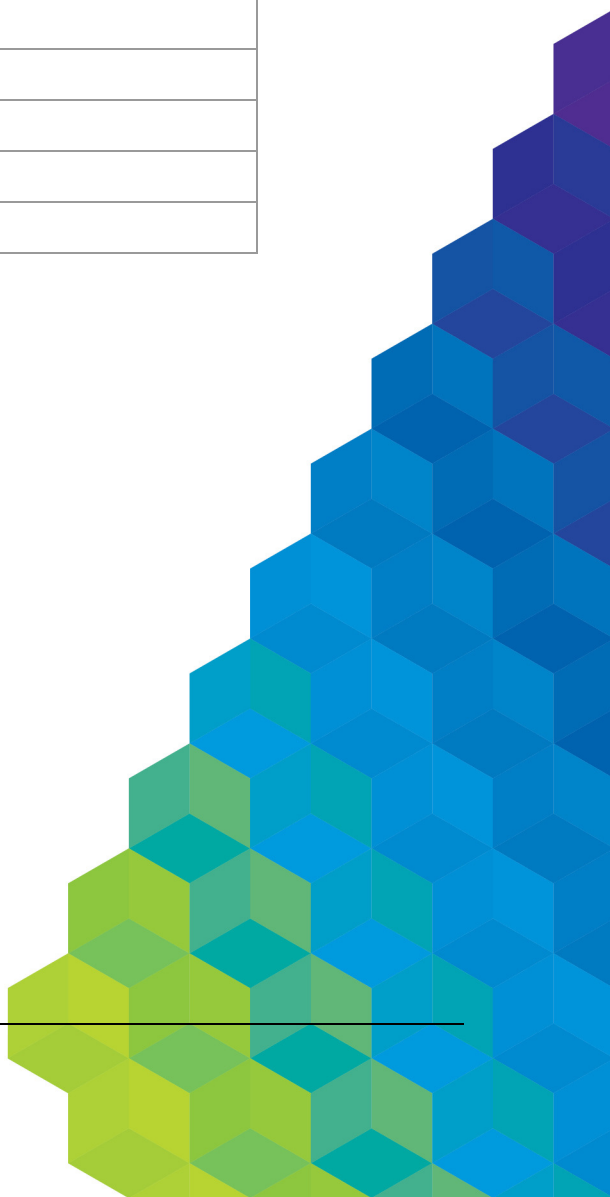

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REVISION HISTORY

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1	09/03/2017	First Issue	J Bernardo A Walsh

1 PURPOSE AND BACKGOUND

1.1 Purpose

The purpose of this supporting document is to explain AusNet Services' strategy in relation to line voltage regulators operating on 22kV networks affected by 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 line voltage regulators 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.

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 ACRs. A separate supporting document is provided in relation to our replacement strategy for that asset.

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.

Line voltage regulators are typically used on long rural 22kV feeders to regulate the voltage. Voltage regulation is necessary as the feeder load leads to voltage drop over the length of the feeder. Options to maintain voltage within allowable limits are to augment the feeder or regulate voltage and the installation of voltage regulation equipment is typically a much lower cost than augmentation of long feeders.

As a consequence of the REFCL program, six line voltage regulators require upgrade and two live voltage regulators require replacement in Tranche 1.

1.3 Strategy objective

The objective of our line voltage regulator strategy is to:

- describe the issues associated with the operation of line voltage regulators on a network utilising REFCLs; and
- demonstrate that a prudent and efficient approach has been taken to the upgrade or replacement of line voltage regulators on AusNet Services' network.

2 Investment need

As mentioned above, line voltage regulators (typically open delta configuration) have been the lowest cost option to regulate voltage on 22kV long rural feeders. Unfortunately they are not compatible with REFCL technology as they displace the system neutral voltage by regulating only two phases (line-to-line voltages), rather than regulating all three phases.

Separately, all line voltage regulators with two phase controllers will also need to be upgraded to a three phase controller ensuring voltages across all three 22kV phases remains consistent and voltage variations between the phases is avoided. All line voltage regulator installations on REFCL networks must be able to regulate voltages on all three phases.

If line voltage regulators are not upgraded or replaced ensuring they are REFCL compatible, uncontrolled voltages will occur on the 22kV network, leading to equipment failure and possible fire starts.

The need to upgrade or replace incompatible equipment, such as line voltage regulators, was highlighted in the REFCL trials:

> *"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 line voltage regulators (in open delta configuration) are upgraded or replaced.

The volume of non-compatible line voltage regulators 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 line voltage regulators 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 line voltage regulators on REFCL protected feeders involves a combination of:

- In the majority of cases, upgrading existing line voltage regulator controller units. This is possible where the regulator unit is still supported by the manufacturer or a three phase controller (required for REFCL operation) can be retrofitted; *and*
- In the minority of cases, replacing line voltage regulators with new AusNet Services' standard units capable of three phase control, resulting in compatible operation with REFCL technology. In these situations, existing line voltage regulators are not able to be upgraded due to the manufacturer no longer supporting the unit and being unable to offer a controller that can regulate all three phases.

Before determining the preferred approach to line voltage regulator modifications, we considered 2 approaches:

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

1. On REFCL protected networks, where still supported by the manufacturer, upgrade existing line voltage regulators so they can regulate three phase voltages. At a small number of locations, where the regulators are no longer supported by the manufacturer, replace units.
2. Same as Option 1, but not upgrading any existing line voltage regulators and replacing all non-compatible units.

Other options that eliminate the need for line voltage regulators were considered but are not viable as they are clearly more expensive than upgrading existing line voltage regulators. The options that eliminate the need for line voltage regulators include upgrading the capacity of lines, relocating zone substations and using embedded generation or demand management to reduce load.

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. Upgrade 22kV line voltage regulators (of open delta configuration) where possible on REFCL networks. In a small number of cases, replace regulators (of open delta configuration) no longer supported by the manufacturer, with units that are compatible with REFCL operation.	Smaller volume of work than Option 2 Works can be completed relatively quickly and do not pose a schedule risk for the REFCL implementation. Lowest cost option $962k.	This option has higher performance risks compared to a replacement only approach. As explained below, this performance risk may also lead to additional rework costs.
2. Replace all 22kV line voltage regulators (of open delta configuration) on REFCL protected networks	Uniform approach. Potential improvements to reliability as new regulators are likely to be more reliable than old regulators.	Works are time consuming and labour intensive. Greater cost than Option 1 at capital cost of $2,800k.

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

A further risk is the timing of the work and ensuring the line voltage regulator works are completed outside the times the regulator(s) are required on the network for voltage support i.e. summer loading or during network transfers. This risk will be mitigated by completing the works prior to summer and co-ordinating the works with other work activities.

While the preferred option has higher performance risks compared to Option 2, the cost saving is substantial. On balance, AusNet Services regards the upgrade and replace strategy to be preferred, 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

4.1 Risk management

The risks associated with delivery of the program for line voltage regulator 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.	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.
Line voltage regulator(s) required for voltage support.	Regulators out of service due to upgrade or replacement activities. Voltage support not able to be provided for downstream customers, leading to low voltages and or outages.	Works to be completed when voltage support is not anticipated to be required. Where regulators are to be replaced works to be constructed alongside existing line regulator units. Cutover to new unit to be undertaken over a reduced period. Decreases time 22kV voltage support is not available from a regulator unit.

4.2 Procurement

Line voltage regulators and control boxes to be installed are 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 line voltage regulators requiring upgrade or replacement in tranche one of the REFCL program varies between zone substations.

The line voltage regulator 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	1
Myrtleford	-	-
Barnawartha	-	-
Kilmore South	1	1
Rubicon A	1	-
Kinglake	-	-
Wangaratta	-	-
Seymour	3	-
Total	**6**	**2**

Source: AusNet Services

4.4 Program costs and benchmarking

The Line Voltage Regulator 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 line voltage regulator replacement or upgrades;
- Bench testing regulator 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

	Cost $000s 2016 direct
Wonthaggi	387
Myrtleford	-
Barnawartha	-
Kilmore South	387
Rubicon A	47
Kinglake	-
Wangaratta	-
Seymour	141
Total	**962**

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 line voltage regulators (referred to as 'Three phase regulators').

The RIS estimate forecast[2] $0 - $375,000 per zone substation.

AusNet Services program, as detailed above, is 0-3 line voltage regulator units per zone substation requiring upgrade or replacement at a range of $0-386,916 per zone substation, which is in line with the RIS estimates. This outcome 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 line voltage regulator 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.

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;

[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.

- 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 line voltage regulator upgrades and replacement is the lowest cost and lowest risk option for addressing the specific issues on REFCL protected networks;
- A standard approach to estimating the costs of line voltage regulator upgrade or replacement has been used;
- The key assumptions underpinning the forecasts are reasonable;
- We have identified the key risks in relation to line voltage regulator modification works and taken appropriate risk mitigation measures; and
- Our upgrade and replacement costs are consistent with the Government's estimated range 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.