ESSENTIAL SERVICES COMMISSION

Electricity Distribution Code – Review of voltage standards for bushfire mitigation

Project scope

February 2018

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1. Introduction

Regulatory framework

The Essential Services Commission (commission) is responsible for licensing electricity distributors in Victoria. As part of our licensing functions under the *Electricity Industry Act 2000* (Vic), we set licence conditions for distributors which include the requirement to comply with the Electricity Distribution Code (code).

The code is made by the commission, and is currently in its ninth version. The most recent revisions to the code were made in December 2015, when we amended the guaranteed service level payment scheme.

The code is a multifaceted and interlinked regulatory instrument serving a diverse stakeholder base. It includes technical, commercial, customer protection and other provisions which regulate and support the operation of the electricity distribution system in Victoria. The code sets out the voltage standards for the distribution system.

Background

In response to recommendations of the 2009 Victorian Bushfires Royal Commission, the Victorian Government established a Powerline Bushfire Safety Program which resulted in new measures to reduce bushfire risks from electricity networks.

The *Electricity Safety Act 1998* (Vic) imposes bushfire mitigation requirements on Victorian electricity distributors. As part of these requirements, on 1 May 2016 amendments to the *Electricity Safety (Bushfire Mitigation) Regulations 2013* (Vic) came into effect which mandated the installation of bushfire mitigation equipment on certain sections of the Victorian distribution network.[1] The current technology available for bushfire mitigation is equipment known as rapid earth fault current limiters (REFCLs).

As a result of the legislation and regulations, electricity distributors propose to install REFCLs at 45 zone substations in high bushfire risk areas specified in the regulations, in three tranches (2019, 2021 and 2023).[2] The vast majority of the REFCLs must be installed by AusNet Services and Powercor, while Jemena must install REFCLs at one zone substation.

[1] Note that high voltage customers may become subject to the bushfire mitigation requirements independently of distributors via the specified operator provisions of the bushfire mitigation regulations.

[2] Note that distributors have already installed, or have received funding to install, REFCLs at a small number of zone substations which are not specified in the bushfire mitigation regulations.

Purpose

This paper sets out our project scope for a review of voltage standards in the code, in the context of the new bushfire mitigation requirements on Victorian electricity distributors.[3]

It also provides contextual information about REFCLs and the regulation of voltage standards.

[3] The obligations in the code apply to all parties which operate and/or use the electricity distribution system. This includes distributors, generators, retailers, exempt entities and customers.

2. Voltage standards

The regulation of voltage standards

The relevant voltage standards are contained in clause 4.2.2 of the code, which sets out the allowable variations from nominal voltage levels that distributors must maintain throughout the network (see extract from the code: clause 4.2.2, Table 1 below).

The variations are expressed in two dimensions:

- level – the extent to which the voltage magnitude can exceed or fall short of the nominal level (e.g. plus or minus 20 per cent)
- duration – the length of time the voltage magnitude can exceed or fall short of the nominal level (e.g. up to one minute).

EDC Table 1 – Voltage standards

STANDARD NOMINAL VOLTAGE VARIATIONS				
Voltage Level in kV	Voltage Range for Time Periods			Impulse Voltage
	Steady State	Less than 1 minute	Less than 10 seconds	
< 1.0	+10% - 6%	+14% - 10%	Phase to Earth +50%-100% Phase to Phase +20%-100%	6 kV peak
1-6.6	± 6 %	± 10%	Phase to Earth +80%-100%	60 kV peak
11	(± 10 %		Phase to Phase +20%-100%	95 kV peak
22	Rural Areas)			150 kV peak
66	± 10%	± 15%	Phase to Earth +50%-100% Phase to Phase +20%-100%	325 kV peak

Other relevant clauses

The interlinked nature of the code means that other provisions may complement clause 4.2.2. These other provisions include:

- Clause 1.6 – Variation by written agreement
  This clause is a negotiating provision which allows for the variation of the code conditions between a distributor and customer by mutual agreement.

- Clause 16(c) – Liability

  This clause requires a business customer to take reasonable precautions to minimise the risk of loss and damage to assets owned by the business customer, which may result from poor quality or reliability of electricity supply.

- Clauses 4.2.6 and 4.2.7 regarding the effect of voltage variations outside the limits specified in Table 1 of the code.

The clauses highlighted above do not constitute an exhaustive list. To ensure a fit for purpose framework for the regulation of voltage standards, in the context of the REFCL roll out, all relevant provisions of the code should be considered.

REFCLs and voltage standards

REFCLs are intended to be installed at distributor zone substations in areas of high bushfire risk where high voltage 'polyphase' electricity lines exist. A polyphase line comprises three electricity lines with each carrying a single phase of electricity.

A REFCL is designed to trigger when an abnormal scenario occurs, such as when one of the polyphase lines fails and then comes into contact with the ground (known as an 'earth fault'), as may occur during extreme weather events. When triggered, the REFCL rapidly reduces the amount of current flowing through the downed line, effectively mitigating the potential of an electrical spark igniting a fire.

As a consequence of the REFCL triggering, the voltage on the remaining two un-faulted lines then 'spikes'. The nature of this voltage spike is a function of the physics of the electricity distribution system. Specifically, when a REFCL triggers, the voltage on the remaining two un-faulted lines is likely to increase from its nominal range by up to 90 per cent.

The voltage spike means that voltage levels in the distributors' network may be outside the allowable range specified in the code.[4] Consequently, for REFCLs to be commissioned, tested or used to respond to a fault (i.e. 'triggered'), they are likely to cause the voltage levels in that part of the distribution network to be in breach of the code.

There are three contexts in which the impact of REFCLs is likely to be experienced. For ease of reference we have defined these contexts in terms of the meter, although in practical terms the relevant boundary will be the connection point, which is not coincident with the meter in all cases. These three contexts, discussed below, are:

- on the network assets owned by the distributor (in front of the meter)

[4] The relevant voltage limits are the distribution high voltage phase to earth parameters. See clause 4.2.2, Table 1 of the code.

- on the assets owned by the high voltage customers (behind the meter)
- on the metering assets, in circumstances where these assets are not owned by the distributor or the customer (at the meter).

The impact of REFCLs on the network – 'in front of the meter' impacts

The voltage spike caused by the operation of a REFCL can 'stress' the distribution network assets. This is because during the periods when a REFCL is triggered, those assets are likely to be operating at a higher voltage level than for which they were designed. This can cause the assets to deteriorate at a faster rate than under normal usage, thereby increasing the risk of equipment failure unless additional action is taken.

The potential for the voltage spike to cause faults elsewhere in the network – a phenomenon called a 'cross country fault' – is relevant because a REFCL can only respond to one fault at a time. If two faults occur in the area of the network that a REFCL 'protects', then the REFCL cannot cope and will disengage, meaning there is no protection against either fault and the bushfire risk is no longer mitigated.

For this reason, the installation of REFCLs must be accompanied by network upgrades to 'harden' the network assets exposed to REFCL operation. These hardening upgrades ensure the network can cope with the increased voltage that will occur when a REFCL is triggered.

The impact of REFCLs on high voltage customers – 'behind the meter' impacts

REFCLs operate on the high voltage network, and therefore any customers connected to the high voltage network will be affected by the voltage spike that occurs when a REFCL is triggered. This is because the nature of high voltage customer connections is such that if the voltage increases in the distributor's network, it also increases in the private network the customer owns and operates.[5]

Unless steps are taken to protect the assets of high voltage customers when the REFCL operates, they will be exposed to the same stresses as the distribution network assets discussed above. That is, they will experience the voltage spike, which may cause faults (e.g. cross country faults).

Just as in the case of cross country faults in the distribution network, faults in the private network of a high voltage customer can lead to increased fire risks, as well as increased risk of other safety incidents and equipment damage.

[5] By contrast, customers connected to the low voltage sections of the network are isolated from the voltage spike by the distributor's existing distribution system transformer assets.

For these reasons, the installation of REFCLs means that steps must be taken to ensure the assets of high voltage customers are either 'hardened' appropriately to cope with the voltage spike, or alternatively 'isolated' from the distribution network so that the voltage spike does not affect their private network.[6]

There are approximately 90 high voltage customers (with 130 connections) that may be affected by the REFCL roll out. These customers can be grouped into three categories:

- government (e.g. defence, utilities, transport, hospitals)
- large private businesses that are multinationals or national conglomerates
- other medium to large private businesses.

The impact of REFCLs on metering assets – 'at the meter' impacts

In some instances, the metering assets for a high voltage customer are not owned by either the customer or the distributor, but rather are the property of a third party (potentially the customer's electricity retailer). This is relevant because metering assets have been recognised as potential weak points that may be more readily affected by the voltage spike caused by the operation of a REFCL.[7] Consequently, these assets will also need to be hardened or isolated. This draws additional stakeholders into the remit of the review.

REFCLs and network reliability

REFCLs were originally designed as a tool to mitigate certain distribution network design issues, with the additional benefit of maintaining and/or improving reliability. In simple terms, a REFCL may improve reliability because when there is a fault on one line, the remaining two un-faulted lines could continue operation, thereby maintaining power supply and reliability for customers connected to those un-faulted lines. This has been one of the key attributes of REFCLs in other international jurisdictions where their installation is standard practice (largely in parts of Europe). The adaptation of REFCLs as a bushfire mitigation measure in Victoria is a world first.

For a REFCL to provide general reliability benefits, it must be programmed to operate in a specific way. The operating modes required to deliver bushfire mitigation benefits are different from the operating modes required to provide full reliability benefits.[8]

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[6] These two options, and their relative cost and risk implications, were the subject of a study by Dr Tony Marxsen which was commissioned by Energy Safety Victoria. Marxsen, Dr Tony 2017, *Customer assets directly connected to REFCL networks: a preliminary risk survey* (http://www.esv.vic.gov.au/pdfs/customer-assets-directly-connected-to-refcl-networks-a-preliminary-risk-survey/).

[7] Ibid, p.24

[8] However, this does not mean the two modes are mutually exclusive. Rather, when programmed purely for bushfire mitigation, the REFCL will not deliver full reliability benefits.

Given that this review has been triggered by the new bushfire mitigation requirements, the focus will not be on the use of REFCLs for reliability purposes.

3. Our review

To ensure the code remains fit for purpose in light of the REFCL roll out, we will review the voltage standards set out in the code.

Objective of the review

Our objective in undertaking this review is to consider whether amendments are necessary to the voltage standards so that distributors can operate REFCLs in accordance with the bushfire mitigation requirements, without breaching the code.

Approach to the review

Our approach to the review is defined in the first instance by our legislative framework. We are guided by our legislative objective to promote the long term interests of Victorian consumers with regard to the price, quality and reliability of essential services.[9]

When making decisions, we must also have regard to certain matters to the extent they are relevant in any particular case, including:[10]

- efficiency in the industry and incentives for long term investment
- the relevant health, safety, environmental and social legislation applying to the industry
- the benefits and costs of regulation … for consumers and users of products or services (including low income and vulnerable consumers) and regulated entities.

The commission's approach to consultation is set out in our *Charter of Consultation and Regulatory Practice* (2012), as well as clause 1.7 of the code.

Areas of focus

We consider the following matters to be of relevance:

- reviewing the parameters of the voltage standards
- reviewing the structure of the voltage standards
- reviewing existing code provisions, or introducing new provisions, to support or complement the REFCL implementation.

There may also be other relevant matters which arise during the course of the review.

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[9] *Essential Services Commission Act 2001* (Vic), section 8.

[10] Ibid, section 8A.