ESSENTIAL SERVICES COMMISSION

Electricity Distribution Code review – Technical standards

Final decision

3 April 2020

An appropriate citation for this paper is:

Essential Services Commission 2020, Electricity Distribution Code review – Technical standards: Final decision, 3 April

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Contents

Executive summary

The Essential Services Commission is the independent regulator that promotes the long-term interests of Victorians with respect to the price, quality and reliability of essential services.[1] We regulate Victoria's energy, water and transport sectors, administer the rate-capping system for the local government sector and regulate the Victorian Energy Upgrades program.

In this final decision, we have made changes to the technical provisions of the Electricity Distribution Code (the code). The code is an operationally focused regulatory instrument, which supports the management of the electricity networks.[2] When making these decisions, we focused on the changes occuring in the electricity sector and how the code should reflect these changes to be fit for purpose. We were also conscious that as technologies develop, there will be greater choices for Victorians and the shift to unlocking these opportunties needs to maintain customer protections.

Our final decision includes the following changes to the code:

- **Introduce flexible voltage standard by adopting the Australian Standard AS 61000.3.100.** The adoption of this standard for the low voltage parts of the distribution system would allow for a more flexible approach to their management. This flexiblity would better enable the uptake of distributed energy resources such as solar photovoltaic and other kinds of distributed energy resources.
- **Maintaining updated customer protection framework.** If customers experience damage to their equipment because of excessive voltage variation, the code works with other regulations to protect customers in such an event. The continuation of this protection measure is important for customers as distributors adopt the flexible voltage standard.
- **Introduce new distributor reporting requirements**. This will require distributors to report on how smart meter technology is being used to improve the management and operation of the distribution system. These changes aim to provide further transparency for customers and policy makers as well as leveraging the capabilities of smart meter technology. For example, using smart meter data gives more visibility of the quality of supply from distributors for the first time. The new reporting requirements also balances and complements the flexible voltage standard.
- **Harmonising with current standards and industry best practice.** Some of the technical standards and definitions referenced in the code are legacy and require updates. Where

[1] Essential Services Commission Act 2001, section 8.

[2] Appendix A of this document provides further information on the purpose of the code

appropriate, these have been updated with current standards, industry best practice and other general updates to make the code fit for purpose.

Code review background

The code has an operational focus and supports the management of the electricity network by setting minimum standards for distribution businesses. It aims to promote system security and provides a level of service protections for Victorian customers. It also covers technical standards that govern the way electricity is supplied and provides customer service standards such as compensation schemes and requirements for how distribution businesses are to communicate with customers.

We launched the code review in December 2018 and we have been progressing this in multiple phases. The first phase of the review, which this final decision paper relates to, focused on the code's technical provisions. The second phase of the code review is currently underway with targeted elements of the customer service standards being considered. We faciliated a focused stakeholder workshop on these matters in February 2020.

We expect the code review to continue beyond customer service standards towards a wider range of matters including; changes in the sector, alternative service models and addressing any remaining items that may remain unresolved. This will also allow the commission to consider new emerging business models or technologies that might interact with the code or other regulatory instruments we administer from 2020-21 onward.

Modernising our technical standards

In this final decision, we have made amendments to the technical standards of the code. Technological advancements are allowing customers to take charge of their energy needs. Examples include installing solar generators or exploring new energy models such as micro-grids and the aggregation of small-scale power generators.

These changes should not be hampered by needless barriers for new energy technologies and service adoption that can provide benefits for Victorian consumers. The regulatory framework must support the operation of these technologies and business models in a manner that supports grid stability, customer safety and protection.

Our final decision will modernise the code's technical standards and also help ensure it remains fit for purpose and for the long-term interests of Victorian consumers. In making our final decision, we considered stakeholder comments and feedback to our draft decision as well as our approach and issues paper and public forums that we facilitated.

Our final decisions

Final decision 1: new voltage standard for more flexibility to the grid

We have implemented a more flexible voltage standard for the code by adopting the equivalent Australian Standard (AS61000.3.100). This standard enables a more dynamic approach towards the management of the electricity distribution system as the sector undergoes significant change. The adoption of the more flexible standard is only applicable for the low-level voltage parts of the network – the parts of the distribution system which normally operates below 1000 volts.

Final decision 2: we are maintaining customer protections for equipment damage by excessive voltage variation

We are maintaining updated fixed voltage parameters in the current code. This allows the continuation of protection for customers to seek compensation. This means customers do not need to demonstrate a detailed cause of damage, should a customer be affected by voltage variation damage. By retaining voltage limits that are fixed for the low voltage range (although we have updated these limits slightly), the code enables the continuation of protection for customers (to a capped limit) through the interaction it has with our existing Guideline 11 – Voltage variation compensation.[3]

Final decision 3: technical standards updated in line with industry best-practice

We have updated the following legacy standards and regulations to promote industry best practice:

- Safety regulation – clause 4.2.1, updated reference to the Electricity Safety (General) Regulations 2019 from the Electricity Safety (Network Assets) Regulations 1999
- Over voltage control – clause 4.2.3, IEC 60364-4-443 updated with IEC 60364-4-44
- Powerline signal – clause 4.2.5, IEC 1000-2-2 updated with AS/NZS 610002.2
- Current harmonics – clause 4.4.3 and 7.6.2, IEEE 519-1992 updated with IEEE 519-2014
- Inductive interference – clause 4.5, AS/NZS 2344-1997 updated with AS/NZS 2344-2016

Final decision 4: harmonise a range of technical standards with the National Electricity Rules and industry best practice

A range of technical standards and clauses have been harmonised with the National Electricity Rules or industry best practice. These include:

[3] Office of the Regulator General, Victoria, Electricity Industry Guideline No. 11 - Voltage Variation Compensation, Version 1, April 2001

- Voltage harmonics – clause 4.4.1 and 4.4.2 harmonised with the National Electricity Rules (Schedule 5.1a, clause S5.1a.6, voltage waveform distortion)
- Power factor – clause 4.3, Table 2 amended. Connection capacity below 100kVA to have their power factor range increased from 0.75 to 0.8 (lagging)
- Negative sequence voltage – clause 4.6 and 7.5 harmonised with the National Elelctricity Rules, Schedule 5.1a, clause 5.1a.7 (voltage unbalance, table S5.1a.1).
- Disturbing load – clause 4.8 harmonised with the National Electricity Rules (Schedule 5.1a, clause S5.1a.5, voltage fluctuations)
- Distributed Energy Resource register - clause 7.9 harmonised with the National Electricty Rules, rule 3.7E. Consequential amendment to clause 9.1.3A to rectify incorrect reference to clause 7.8
- Generating unit – definition harmonised with the National Electricity Rules to be technology neutral.

Final decision 5: introduce new obligations for distribution businesses to report on how they are using the information from smart meter technology

We have introduced new distributor reporting requirements on how the information from smart meter technology is being used to enhance the management and operation of the distribution system. These changes aim to provide further transparency for policy makers and customers. Consequential amendments to clauses 3.5.1(e), 3.5.3C, new definitions and schedule 1 have been made.

Final decision 6: other technical standards to remain unchanged

Based on our review, we propose not to change the standards relating to minimum technical requirements for embedded generation, supply frequency, impulse voltage, Rapid Earth Fault Current Limiter time duration, load balance and fault level.

Final decision 7: commencement date of code amendments

We will give effect to the code amendments on 3 April 2020.

How to contact us

General enquires

If you have other general enquires or enquiries about the code, you can contact us by:

Phone: (03) 9032 1300

Email: edc.review@esc.vic.gov.au

Website: https://www.esc.vic.gov.au/

Post: Attention: Energy division
Essential Services Commission
Level 37, 2 Lonsdale Street
Melbourne Vic 3000

1. Final decision context

The Electricity Distribution Code

The code is a multi-faceted regulatory instrument with an operational focus to support the management of the electricity networks. It sets the minimum standards for the distribution networks, promotes system security and provides a level of service standard and protections for Victorians. The code covers areas such as:

- Protections for customers, such as when customers will be compensated for low reliability
- Communication requirements, such as when distribution businesses are to contact customers before a planned outage
- Certain process requirements, like new customer or generator connections and
- Technical standards that govern the way electricity is supplied.

The technical standards in the code seek to promote the safe and efficient distribution of electricity through our community. Distributors must comply with these standards as a condition of their licence and have the primary responsibility to manage the network within the standards.

The code forms one part of the regulatory framework supporting the development, management and operation of Victoria's electricity network.

Appendix A provides further information on our role and the purpose of the code.

Stakeholder feedback to our issues paper

Our August 2019 issues paper highlighted a range of emerging technical matters that we considered important to review. These included voltage standards, customer protection and technical standards that may interact with new business models. In general, stakeholders agreed that these were the key issues facing the electricity grid. Stakeholders also expressed support for aligning and harmonising technical standards with Australian industry norms or best practices. The stakeholder submissions are publicly available on our website.

Stakeholder feedback to our draft decision

In December 2019, we published our draft decision on the proposed changes to the code to address the key technical matters identified in the issues paper. The draft decision reflected stakeholder feedback provided in response to our issues paper. Stakeholders were encouraged to provide submissions in response to the proposed draft decision amendments, and most submissions expressed support for our proposed amendments. We received seven stakeholder submissions to our draft decision, which are publicly available on our website.

2. Flexible voltage standard for the grid

We are introducing a more flexible voltage standard in the code by adopting the Australian Standard. This standard better aligns with changes occurring in the electricity sector such as, recent government policy supporting small-scale generation, emerging community interest with electric vehicles and to further assist with managing the network.

Voltage is a characteristic of electricity and by extension the power system. A useful analogy to think of voltage is like water pressure in pipes. Pressure is necessary for water to flow through the pipes. The higher the pressure, the faster it flows. Similarly, voltage could be thought of as the electrical pressure for the power system. Too high or not enough voltage could lead to equipment becoming inoperative or malfunctioning across the system.

Clauses 4.2.1, 4.2.2 and 4.2.2A of the code sets out the voltage standards.

In our issues paper and draft decision, we highlighted how the code sets technical standards for distributors to regulate the supply arrangements between customers and distributors. This is to achieve a safe and technically manageable electricity grid.

We also highlighted how Victoria's electricity network is changing, with the increased uptake of distributed energy resources including solar generators and batteries across the networks as well as an emerging interest in electric vehicles. This change creates opportunities to improve the operation of the network, including the ability to better manage demand in peak periods. It also creates challenges, such as managing voltage within the levels prescribed by the code, to which a range of industry projects are researching and exploring.[4]

Flexible voltage standard

We are introducing the Australian Standard for voltage management to the code. This standard promotes flexbility in managing voltage for the grid.

Most stakeholders expressed support in adopting the Australian Standard to enable flexible voltage management, performance monitoring and maintaining customer protection.

[4] Networks renewed, ARENA, https://arena.gov.au/projects/networks-renewed/

Final decision 1: new voltage standard for more flexibility to the grid

We are introducing a more flexible voltage standard by adopting the equivalent Australian Standard (AS61000.3.100). The standard would enable a more dynamic approach towards the management of the distribution system as the sector undergoes significant change, for example, a greater volume of rooftop solar.

The introduction of the flexible voltage standard will appply to the low-level voltage parts of the network (i.e. below 1000V). We have made amendments to clause 4.2.2 of the code, which sets out the standard relating to voltage limits.

Figure 1 illustrates how the low voltage parameters of our standard currently apply to distributors for customers set out in clause 4.2.2 of the code. Under steady state conditions (or normal, business-as-usual conditions), distributors are to manage voltage within a fixed limit. This is not the case for non-steady state conditions, such as periods of less than one minute or ten seconds, where distributors are only required to use its best endeavours to manage voltage within limits – this is for abnormal conditions where voltage fluctuations may not instantly be controllable.

Figure 2 illustrates the comparison between the code's current voltage standard and the Australian Standard. The Australian Standard for voltage replaces the fixed limits of the code with a more flexible statistical based approach.

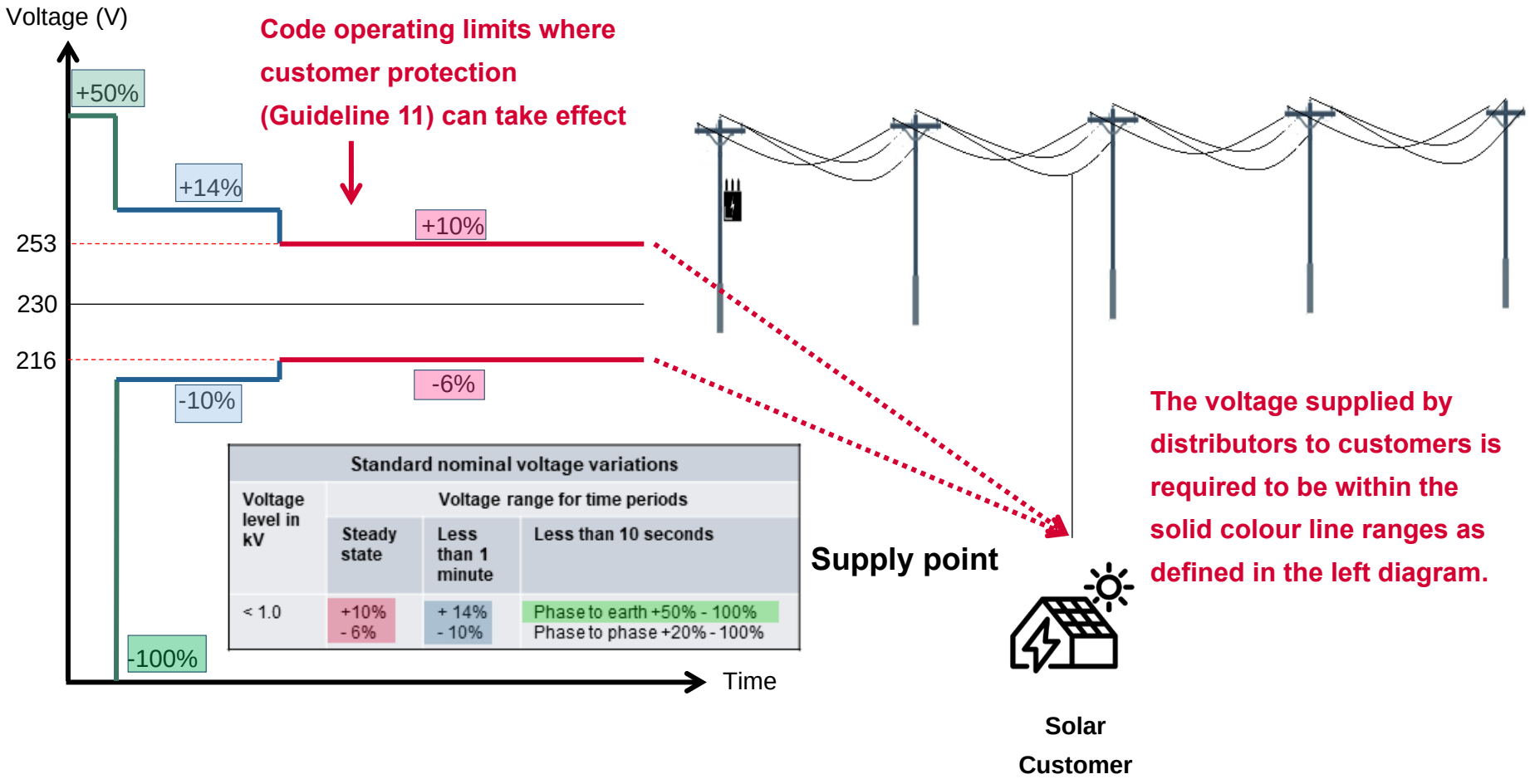
In practice, this means that distributors would not strictly manage voltage levels within the fixed limits of the code. However, under the statistical approach, distributors would still aim to manage voltage levels to be within the limits for 99 percent of time for customers on the network as prescribed by the Australian Standard.

This approach to flexible voltage management would allow for a more dynamic system, where distributors could adjust and optimise the network to suit more local conditions. This flexibility would also support and align with other initiatives such as the voltage response measures proposed in the Australian Energy Market Operator's Technical Integration of Distributed Energy Resources report.[5]

The flexible voltage standard should also translate into opportunities for distributors to be more efficient in their approach to investment when managing the quality of supply. This combined with the fixed customer protection voltage limits should provide clarity for the Australian Energy Regulator with their considerations.

[5] Australian Energy Market Operator, Technical Integration of Distributed Energy Resources, p50 – 51, April 2019

Figure 1– Electricity distribution code voltage standard (current)

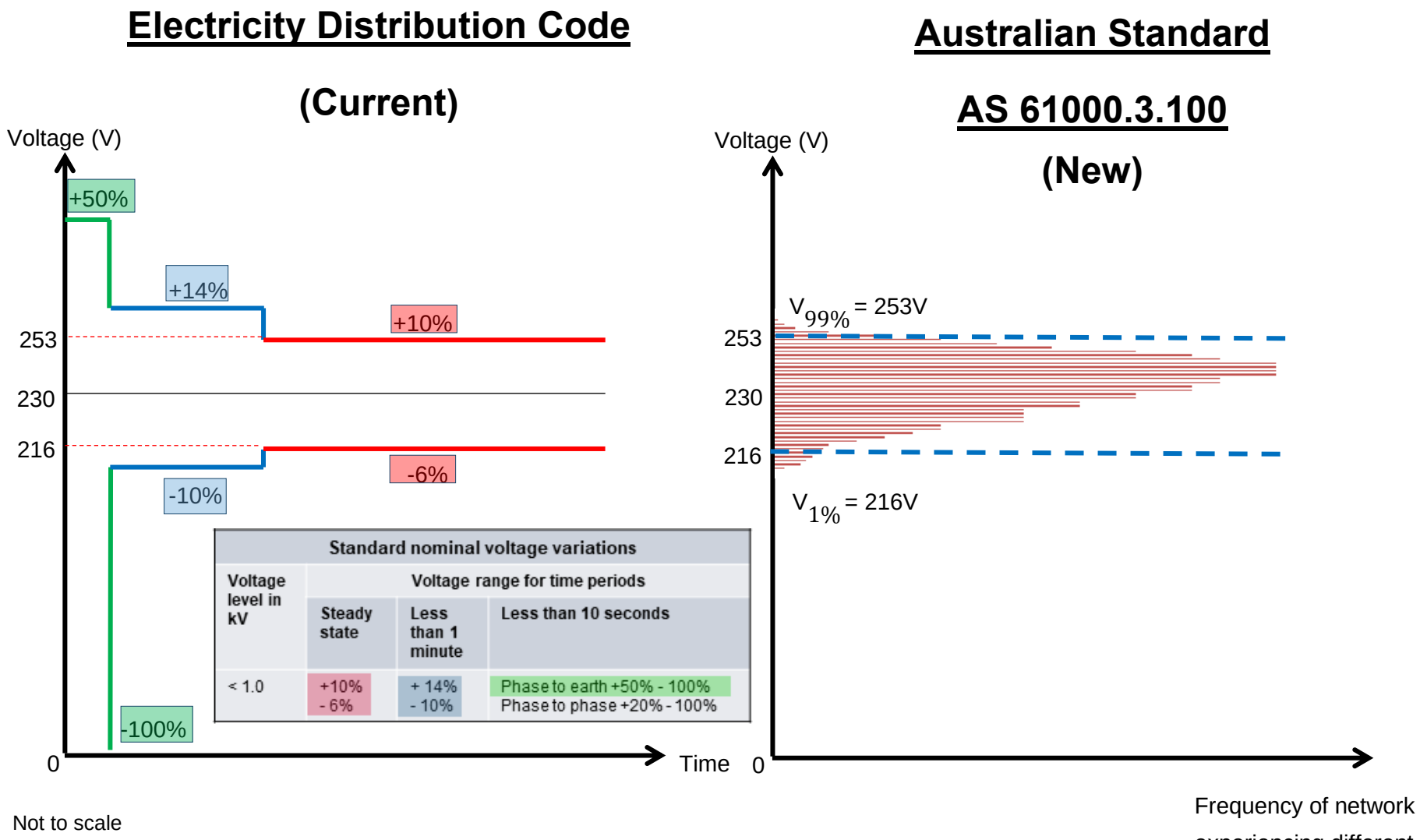


Standard nominal voltage variations

Voltage level in kV	Voltage range for time periods		
	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%

Not to scale

Figure 2 – Comparison between the current voltage standard and the new Australian Standard (AS 61000.3.100) for voltage to be adopted for the Electricity Distribution Code



Not to scale

Updated requirements for reporting on voltage management performance

Given the flexibility provided to distributors to manage voltage, we would expect distributors to expand their monitoring of power quality to track voltage performance. With the deployment of smart meters across Victoria, we believe there are further opportunities to explore and leverage the capabilities of this technnology. Additionally, making this information more accessible and transparent to the public could promote innovation for new energy models to explore where non-network opportunities can be generated for customer benefits.

To complement the introduction of the flexible voltage standard, distributors will be required to report annually and publicly on power quality information such as voltage. The new clause 3.5.3C and updated clause 4.2.6 of the code reflects these new reporting requirements. Further information on these reporting changes are set out in our final decision 5 section of this paper.

Consequential updates on standards for voltage variation frequency

In light of the flexible voltage standards being adopted, we have made a consequential update to clause 4.2.4 (voltage variation frequency) of the code. This clarifies the one minute swell limits not being applicable for the low voltage range in table 1 of the code. Put another way, due to the statistical approach of the Australian Standard AS 61000.3.100, the one minute swell limits for the low volatge range do not apply for table 1 of the code. For the high voltage range of table 1, the one minute swell limits do apply.

Stakeholder feedback

All stakeholder submissions to our draft decision supported adopting the flexible approach to voltage management as set out in the Australian Standard (AS 61000.3.100). This includes stakeholders across consumer groups, distributors and retailers, providing the following comments:

> "We (the Energy and Water Ombudsman of Victoria) expressed the view that adopting the Australian Standards (AS 61000.3.100), as South Australia and New South Wales have done (with Queensland in the process) is preferable to taking a 'best endeavours' approach because it provides more certainty". [6]
>
> "The Clean Energy Council strongly supports the proposal to utilise the statistically based approach to voltage standards in the code by adopting the equivalent Australian Standards (AS 61000.3.100)". [7]

[6] The Energy and Water Ombudsman of Victoria, submission to the Essential Services Commission draft decision, p2, 20 January 2020

[7] Clean Energy Council, submission to the Essential Services Commission draft decision, p2, 17 January 2020

> "Red and Lumo have reviewed the draft decision and support the amendments made to it". [8]

> "We (Jemena) welcome the proposed adoption of the voltage standards equivalent Australian Standards". [9]

We note that the Australian Standard AS 61000.3.100 covers both low and high voltage levels.[10] If adopted in its entirety, the Australian Standard would then also replace the high voltage range of the code.[11] We consider this is inappropriate due in part to how the standard (AS 61000.3.100) could interact with other Victorian regulatory obligations, if adopted for differing voltage levels.

In 2018, we conducted a voltage review of the code to enable the introduction of advance bushfire safety technology called Rapid Earth Fault Current Limiter (REFCL) at the high voltage level. This took into consideration the requirements of the electricity safety legislation.[12] If the Australian Standard (AS 61000.3.100) was applied to the high voltage level (i.e. 22kV), a statistical cap may unintentionally affect the normal operation of REFCL. This would go against our approach in our 2018 review, which sought to support the delivery of bushfire mitigation requirements and where appropriate, the appropriate use of REFCL technology.[13]

Due to the operation of REFCL technology in Victoria, we will apply the Australian Standard AS 61000.3.100 to the low voltage range (below 1000V) and not the high voltage parts of the distribution system (above 1000V). Our amendments to table 1 of clause 4.2.2 of the code reflects this approach.

We are maintaining customer protections

The existing voltage standard of the code are also linked to a guideline we administer, known as Guideline 11 – Voltage variation compensation.[14] This guideline complements the code by allowing a customer to seek compensation for damage (through the guideline process to a capped limit), should they be affected by voltage levels that exceed the existing fixed limits of the code. Table 1

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[8] Red and Lumo energy, submission to the Essential Services Commission draft decision, p1, 20 January 2020

[9] Jemena Electricity, submission to the Essential Services Commission draft decision, p1, 3 January 2020

[10] Australian Standard AS 61000.3.100-2011, sections 5.1 - 5.2

[11] High voltage is defined as exceeding 1,000V (AC), Australian Standard AS 3000, clause 1.4.128, (c)

[12] Electricity Safety Act 1998

[13] Essential Service Commission, Electricity Distribution Code – Review of voltage standards for bushfire mitigation, final decision, 14 August 2018

[14] Clause 4.2.7 links the existing voltage standards of the code to Guideline 11, when dealing with customer compensation.

shows that during 2018-19, there were over 2,000 compensation claims made to distributors under Guideline 11. Of these, 179 cases were raised with the Energy and Water Ombudsman of Victoria for resolution.

Table 1 – Guideline 11 compensation cases (FY 18/19)

Distributor	Distributor total customer numbers[15]	Distributor Guideline 11 compensation numbers	EWOV Guideline 11 cases[16]
Ausnet Services	666,021	398	179
Citipower	268,668	165	
Jemena	325,214	100	
Powercor	709,793	891	
United Energy	623,481	456[17]	
Total	2,589,177	2010	179

We understand that adopting a flexible voltage standard might create ambiguity for customers or distributors in relation to how Guideline 11 would apply or should be interpreted. In our draft decision, we proposed retaining an updated version of the fixed voltage limits to enable clarity regarding compensation that could apply. Our final decision retains an updated version of these fixed voltage limits to ensure that customers can have clear expectations of where the protection threshold starts, should equipment damage occur that satisfies the conditions. We have included schedule 2 in the code as additional guiding notes.

Stakeholder feedback

Stakeholders such as the Energy and Water Ombudsman of Victoria, the Clean Energy Council, Red Energy and Lumo Energy supported our approach to retaining the existing protections for customers provided by the code and Guideline 11, noting the following:

> "We (the Energy and Water Ombudsman of Victoria) are pleased that the ESC has proposed to retain a modified version of the existing voltage limits of the code for the purposes of customer compensation and wholeheartedly support this decision". [18]

[15] Defined as residential electricity active account owners with unique customer IDs

[16] The Energy and Water Ombudsman of Victoria submission, p2, 9 September 2019

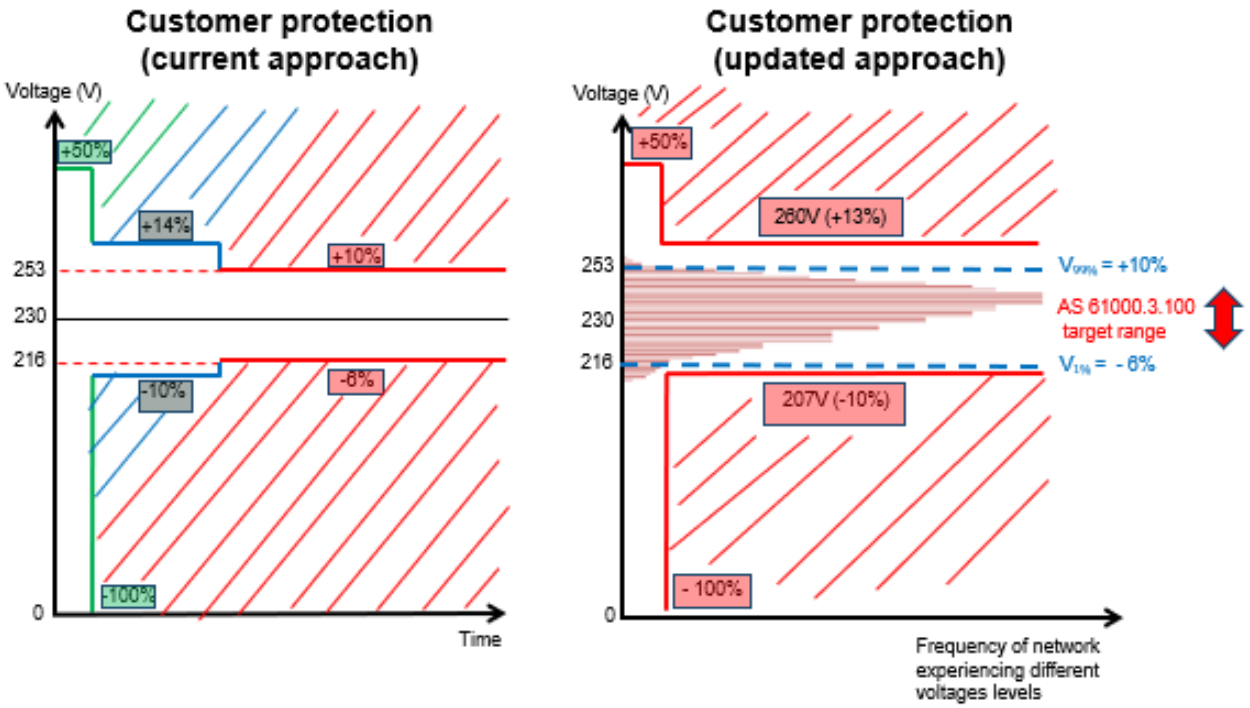
[17] United Energy figures are only for the first half of 2019 due to migration to a new reporting platform

[18] The Energy and Water Ombudsman of Victoria, submission to the Essential Services Commission draft decision, p3, 20 January 2020

> "The retention of a modified version of the existing fixed voltage limits of the code for the purposes of customer compensation will ensure that customers are not disadvantaged by the proposed changes. We (the Clean Energy Council) support the proposal to increase the upper and lower voltage limit to +13% and -10% (from +10% and -6% respectively)". [19]
>
> "Red and Lumo support the Commission's draft decision to continue to link the existing voltage standards to Guideline 11 – Voltage variation compensation". [20]

Other stakeholders who made submissions did not provide comment on this matter. Therefore, we are retaining an updated version of the fixed voltage limits of the code, for the purposes of customer compensation. Figure 3 illustrates how the customer protection limits would change from the current format (left diagram) to the approach taken in this final decision (right diagram). For both cases in figure 3, the colour shaded regions represents where the respective customer protection approaches becomes enabled for Guideline 11 to take effect.

Figure 3 – Comparison of customer protection between current and the final decision updated approach.



We expect that distribution businesses would manage their network voltage in accordance with the flexible Australian Standard, but be subject to the customer protection limits, should performance

[19] The Clean Energy Council, submission to the Essential Services Commission draft decision, p2, 17 January 2020

[20] Red and Lumo Energy, submission to the Essential Services Commission draft decision, p1, 20 January 2020

exceed. This will then continue similar levels of protections for customers, while allowing flexible standard for managing voltage. Retaining the updated version of the fixed voltage limits, also sets out a clear standard of entitlement to compensation for customers using Guideline 11 and reduces the administrative or dispute process for customers and distributors.

Final decision 2: we are maintaining customer protections for equipment damage by excessive voltage variation

We are maintaining updated fixed voltage parameters in the code to enable a customer to seek compensation for damage (through the guideline process to a capped limit), should customers be affected by voltage variations.

These voltage parameters are set out in table 1 of the code to continue their operation with our existing guideline 11 – voltage variation compensation.

Clauses 4.2.2 and 4.2.7 of the code sets the conditions that can bring about guideline 11 – voltage variation compensation.

The updated fixed voltage parameters are a simplified and consolidated version of the code's original fixed limit of table 1, by combining the previous steady state and one minute voltage limits. It should be noted that we are increasing the upper and lower voltage limit to +13 percent and -10 per cent (from +10 per cent and -6 per cent respectively). These changes aim to align with similar voltage parameters set out in the revised basic connection agreements proposed by distributors and approved by the Australian Energy Regulator.[21] These revised limits would also align with the voltage response approach proposed in the Australian Energy Market Operator's Technical Integration of Distributed Energy Resources report[22] as well as comply with the mandated features promoted by Solar Victoria's solar homes program.[23]

[21] Ausnet, Services submission to the Essential Services Commission issues paper, p11, 13 September 2019

[22] Australian Energy Market Operator, Technical Integration of Distributed Energy Resources, p50 - 51

[23] Solar Victoria Notice to Market - Solar Homes Program, p28 – 30, 27 August 2019, version 3

3. Modernising existing technical standards

The code has not been substantively reviewed for many years, and the industry has adopted a number of new standards (Australian Standards or internationally-recognised standards) or new regulations have come into effect that had yet to be reflected in the code. Our review has now updated several provisions and references in the code with current industry practices, technical standards, other relevant regulations, jurisdictional approaches and frameworks.

This chapter sets out various updates made to the code including those that are being updated with current standards in line with industry norm or industry best practices. In other areas, provisions are being harmonised with other frameworks and approaches. Where relevant we have also updated references to the code which may not be technical in nature such as the safety regulations or made clarifications.

Updating standards in line with industry norms and best-practice

This section sets out the updates made to the code including the safety regulations, over voltage control, powerline signals, inductive interference and harmonics.

Final decision 3: technical standards updated in line with industry best-practice

The code's legacy standards and regulations have been updated in line with industry best-practice, to ensure that the code remains fit for purpose. Updates to the following standards have been made for the code:

- Safety regulation – Clause 4.2.1, updated reference to the Electricity Safety (General) Regulations 2019 from the Electricity Safety (Network Assets) Regulations 1999
- Over voltage control – Clause 4.2.3, IEC 60364-4-443 updated with IEC 60364-4-44
- Powerline signal – Clause 4.2.5, IEC 1000-2-2 updated with AS/NZS 610002.2
- Current harmonics – Clause 4.4.3 and 7.6.2, IEEE 519-1992 updated with IEEE 519-2014
- Inductive interference – Clause 4.5, AS/NZS 2344-1997 updated with AS/NZS 2344-2016

Stakeholder feedback

All stakeholder feedback across consumer groups, distributors and retailers supported our proposed updates including several technical standards in the code in line with Australian Standards or industry best-practice. For example, the Energy and Water Ombudsman of Victoria, CitiPower, Powercor, United Energy, Red Energy and Lumo Energy stated the following:

> "Again, we (the Energy and Water Ombudsman of Victoria) support the ESC's decision here". [24]

> "We (Citipower, Powercor and United Energy) welcome and support the ESCV draft decision to align the technical standards requirements with the Rules or current Australian Standards, thereby moving towards a nationally consistent approach". [25]

> "Red and Lumo Energy supports the Commission's draft decision to modernise the technical standards that apply within the Electricity Distribution Code". [26]

Over voltage control

For many years our code has referred to older industry standards to prescribe what network controls must be in place to manage voltages spikes of various origins. The older standard, International Electrotechnical Commission (IEC) 60364-4-443 has been superseded to IEC 60364-4-44, which we have now updated (referred to in clause 4.2.3 of the code).

This standard (IEC 60364-4-44) requires distributors to manage weather-related or switching-induced overvoltage to protect the network. The new standard is an update to the old standard, its application should not materially affect the current management of the network and should reflect current industry practices where applicable.

Powerline signal

The code includes provisions that allow distribution businesses to use the powerlines for communication purposes or to send signals to control equipment across the network, including at customer sites.

One distribution businesses stated in their submission to our issues paper that powerlines are no longer used to carry communication or control sigals. [27] However, new energy schemes like the management of distributed energy resources may seek to explore and innovate in this space. We believe that this medium has growth potential and retaining this standard, updated to its modern equivalent may serve as a prudent base line reference. This standard would also interact with

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[24] The Energy and Water Ombudsman of Victoria, submission to the Essential Services Commission draft decision, p2, 20 January 2020

[25] Citipower, Powercor and United Energy, submission to the Essential Services Commission draft decision, p1, 17 January 2020

[26] Red and Lumo Energy, submission to the Essential Services Commission draft decision, p2, 20 January 2020

[27] Citipower, Powercor and United Energy, submission to the Essential Services Commission issues paper, p15, 13 September 2019

managing things such as inter-harmonics as more high capacity power electronic equipment becomes connected to the distribution system.[28]

Therefore, our final decision is to update the powerline signal provision of the code with clause 4.2.5 being updated with the current equivalent standard (AS/NZS 61000.2.2). This standard is designed to manage things like inter-harmonics emissions that are generally associated with high frequency signals, which could originate from power electronics and communication equipment.

Inductive interference

The code includes standards to manage the level of interference on communication equipment as a result of operating the electrical distribution system. This problem is known as inductive interference, and is caused by electromagnetic interference that can affect communication equipment such as radios or telephones.

We have updated clause 4.5 of the code to reference the current standard (AS/NZS 2344-2016) from the legacy standard (AS/NZS 2344-1997). We understand that these changes should reflect current industry norm and practices to not materially affect the management and operation of the grid.

Current harmonics

Harmonics is a measure of power quality (and describes the level of distortion in the pure sine wave of the power system ideal for all equipment).

High levels of harmonics (irrespective of electrical current or voltage) can lead to the wastage of electricity, but this should be balanced against the cost to mitigate, which both distributors and customers have responsibilities to manage. For example, distributors must manage the network voltage harmonic limits and customers should be installing equipment that does not distort the harmonics outside the limits.

Clauses 4.4.3 and 7.6.2 sets the current harmonics standards of the code

The code includes harmonics (electrical current) standards that is unique to Victoria. We were unable to identify a direct equivalent Australian Standard, which could substitute what the code currently prescribes. We are therefore updating the Institute of Electrical and Electronics Engineers standard (IEEE 519-1992) with the current standard (IEEE 519-2014) for clause 4.4.3 and 7.6.2 of the code.

[28] Inter-harmonics are harmonic components, which are not a multiplier of an integer (i.e. whole numbers 1, 2, 3 etc.…), but a decimal number (i.e. 1.3, 2.7, 3.9 etc.) of the fundamental frequency.

Updated references to safety regulations in Victoria

The code currently refers to the Electricity Safety (Network Assets) Regulations 1999 in the context of maintaining a nominal voltage level at the point of supply. The safety regulator, Energy Safe Victoria, has recently updated their regulations and we have updated the code to reflect this under clause 4.2.1.

Harmonising relevant Victorian standards with the National Electricity Rules

The code contains many technical standards that have applied to the Victorian electricity distribution system for more than a decade. Some of these standards have been in place since the distribution system was managed and operated by the State Electricity Commission of Victoria until the 1990s.

Since then, new rules and standards have been introduced for the operation of distribution networks across Australia. Some of these standards are included as part of the National Electricity Rules, which apply to the connected networks of Queensland, New South Wales, Australian Capital Territory, South Australia, Tasmania and Victoria. Where appropriate, we have aligned relevant jurisdictional technical standards with the National Electricity Rules or industry best practice, particularly for standards relating to power factor, negative sequence voltage and disturbing load.

We have also updated references and definitions to provide clarity for stakeholders and to avoid unnecessary duplication, such as linking with the national requirements to maintain a register of distributed energy resources.

Final decision 4: harmonise a range of technical standards with the National Electricity Rules and industry best practice

We have harmonised a range of technical standards and clauses with the National Electricity Rules or adopted industry best practice. These include:

- Voltage harmonics – clauses 4.4.1 and 4.4.2 harmonised with the National Electricity Rules, Schedule 5.1a, clause S5.1a.6 and current Australian Standards.
- Power factor – clause 4.3, table 2 amended to increase power factor range from 0.75 to 0.8 (lagging) for up to 100kVA capacity services.
- Negative sequence voltage – clause 4.6 and 7.5 harmonised with the National Electricity Rules, Schedule 5.1a, clause S5.1a.7 (voltage unbalance, Table S5.1a.1).

- Disturbing load – clause 4.8 harmonised with the National Electricity Rules, Schedule 5.1a, clause S5.1a.5 (voltage fluctuations)
- Distributed Energy Resource register - clause 7.9 harmonised with the National Electricity Rules, rule 3.7E (register of Distributed Energy Resources). Consequential amendment made to clause 9.1.3A to rectify an incorrect reference to clause 7.8.
- Generating unit – definition harmonisation with the National Electricity Rules to be technology neutral

Stakeholder feedback

Stakeholder submissions supported our draft decision to harmonise the code where appropriate. For example, Jemena, the Energy and Water Ombudsman of Victoria and the Clean Energy Council provided the following comments:

> "We (Jemena) welcome… harmonisation of the relevant technical standards and clauses in the Code with the National Electricity Rules". [29]
>
> "The Energy and Water Ombudsman of Victoria - Given the interconnection of Victoria's Grid with other parts of the NEM, there seems little benefit in maintaining distinct technical standards for Victoria if harmonisation with the National Electricity Rules (NER) can be easily achieved at no detriment to distributors and customers". [30]
>
> "The Clean Energy Council supports the proposals to harmonise Victorian standards with the National Electricity Rules with respect to voltage harmonics, power factor and negative sequence voltage. We support the proposal to update the definition of a 'generating unit' to be technology neutral so that it can account for generation technologies such as solar and battery storage. We support the proposal to avoid unnecessary duplication by aligning Victorian requirements for distribution businesses to maintain a register of embedded generators with AEMO's proposal DER Register". [31]

Voltage harmonics

We have harmonised the voltage harmonics standard of the code with the National Electricity Rules. We consider this change provides a consistent approach for stakeholders to manage

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[29] Jemena Electricity, submission to the Essential Services Commission draft decision, p1, 3 January 2020

[30] The Energy and Water Ombudsman, submission to the Essential Services Commission draft decision, p2, 20 January 2020

[31] The Clean Energy Council, submission to the Essential Services Commission draft decision, p2, 17 January 2020

harmonics on the distribution system and offer increased flexibility for the grid as it faces new types of connections.

The distribution system should be designed and operated to maintain total harmonics within prescribed limits for differing voltage levels. Harmonics is a measure of the quality of supply distortion that results in energy wastage. Total harmonics consists of the summation of smaller components added up to form the level of distortion allowed for a given part of the network. This measure is called Total Harmonic Distortion (THD). When the total harmonics level becomes too high for a particular point on the network or customer connection, it could affect the operation of the wider network and must be managed to appropriate limits.

The code currently prescribes a limit of 3 per cent THD for the high voltage range in table 1 of the code. However, the Australian Standard prescribes limits between 3 per cent to 6.5 per cent THD for different high voltage ranges. Further information is provided in appendix E.

In submissions to our issues paper, distributors provided differing views on whether we should change the voltage harmonic limits of the code to harmonise with the National Electricity Rules. AusNet Services did not advocate for change to the existing standard, stating the following:

> "Distribution business have deployed substantial numbers of Rapid Earth Fault Current Limters (REFCLs) to prevent the ignition of bushfires … does not support adopting AS 61000.3.6 and recommend retaining existing harmonic distortion limits to avoid deterioration of REFCL performance or associated costs to resolve" [32]

Jemena, Citipower, Powercor and United Energy in their submissions to our issues paper supported harmonising our standard with the national framework, stating:

> "we support harmonising with the Rules by deleting clauses 4.4.1 and 4.4.2 of the EDC, but retaining clause 4.4.3. However, we note that the operation of REFCLs and the impact on harmonics needs to be further considered" [33]

> "…Adopting the AS in the code for harmonic voltage will not worsen the issue at REFCL substations….. We recommend the adoption of AS TR IEC 61000.3.14-2013 for harmonics for low voltage electrical installations and AS 61000.3.6-2012 at medium and high voltage installations." [34]

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[32] Ausnet Services, submission to the Essential Services Commission issues paper, p12, 13 September 2019

[33] Citipower, Powercor and United Energy, submission to the Essential Services Commission issues paper, p26, 13 September 2019

[34] Jemena Electricity, submission to the Essential Services Commission issues paper, p4 and p11, 13 September 2019

Our draft decision recognised the concerns of distributors in managing voltage harmonics particularly where REFCL are operating on parts of the network. It is important to note that the deployment of bushfire mitigation technology is mandated by the Victorian electricity safety legislation with expected completion of the rollout by 2023. [35]

AusNet Services stated in their submission to our issues paper the scenario where harmonics levels could affect the operation of the REFCL technology as follows:

> "REFCL performance and ability to perform this task becomes compromised by harmonic voltage distortion greater than 2%" [36]

Our draft decision noted the Ausnet Services submission. However, we understand that the code's existing voltage harmonics standard of 3 per cent THD already exceeds the more stringent performance requirements placed on the operation of REFCL at 2 per cent THD. These more stringent performance requirements are dictated by the Victorian electricity safety legislations and supporting framework. It would also only apply to parts of the network where REFCL are operating. In parts of the network where REFCL are not being deployed, the standards as set out in the code would apply.

We recognise that the mandated deployment of REFCL only covers approximately 20 per cent of the total number of distributor zone substations in Victoria. The remaining 80 per cent of zone substations are currently not included in the REFCL program. In those areas where REFCL are not currently deployed, we recognise that the code sets voltage harmonics limits more stringently than the Australian Standard, but not to the extent that REFCL require. These limits have been in the code for more than a decade and provides less flexibility for distributors in managing the grid compared to interstate networks.

Therefore, we have harmonised our voltage harmonics limits with the National Electricity Rules and Australian Standard. This will align with normal industry practices in Australia to cover most of the Victorian distribution system. This should result in more optimised investment by distributors when managing voltage harmonics to most parts of the Victorian network, where REFCLs are not deployed. In areas of the network where REFCL are operating, the more stringent harmonic limits set out by the electricity safety legislation will supersede the voltage harmonic limits of the code. We are not changing the harmonic standards relating to electrical current, which is discussed further in chapter 4 of this paper.

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[35] Electricity Safety Act 1998

[36] Ausnet Services, submission to the Essential Services Commission issues paper, p12, 13 September 2019

Power factor

Power factor is a measure of the efficient use of electricity. The closer a customer's power factor is to 1 (or unity), the more efficient their usage would be. For example, a small welding machine may have relatively poor power factor compared to a washing machine or a dish washer. Unless measures are taken to improve power factor, higher electricity consumption or wastage would result.

Clause 4.3 of the code sets the power factor standards

We reviewed power factor standards that apply in other state jurisdictions and the National Electricity Rules against those in Victoria (see appendix D). We found that Victoria has the lowest minimum power factor value of 0.75 (lagging).

Power factor standards can help optimise the operation of distribution system and equipment. For example, solar inverters are generally designed to operate effectively within certain power factor ranges. We understand that the industry is undertaking exploratory works to better understand how to manage coincidence factors. However, we do not expect customer loads and any locally installed generation to behave coincidentally to mitigate power factor matters unless there is direct management or interaction between devices.

To harmonise with industry best practice and for better alignment with current equipment performance, we have increased the lagging power factor minimum range from 0.75 to 0.8. This applies to services below 100kVA capacity (as per clause 4.3.5, table 2 of the code).

This updated standard clarifies the expected power factor range for distributors when planning upgrades to the network. The standard also provides an appropriate signal for customers to maintain or improve their power factor, given it is a 'best endeavour' provision in the code.

Negative sequence voltage and disturbing load

Negative sequence voltage is part of an analytical method used in electrical engineering. It describes the voltage being in reverse rotation from the power system's normal rotation. During normal system operation, the presence of negative sequence could be a sign of some system imbalance due to a range of factors.

One way to picture negative sequence is the unbalanced wobble of a spinning fan blade, if the weight or shape of one blade is different to the other blades.

Clause 4.6 of the code sets the negative sequence limits.

Disturbing loads come from equipment or plant which, by their operation, may affect supply quality at the connection point. Such equipment must be designed, installed and operated to manage this.

Clause 4.8 of the code sets the disturbing load standards.

The existing standards relating to the management of negative sequence voltage and disturbing loads in the code have been supersed by updated technical standards, which have also been adopted by the National Electricity Rules. The relevant standards of the code have been in place for over a decade, and do not necessarily represent current industry practice when managing these network characteristics.

We have therefore harmonised our standard for negative sequence voltage with the National Electricity Rules for both distributors and embedded generators (clause 4.6 and 7.5 of the code respectively). Appendix F provides a comparision of the negative sequence voltage between our code and the National Electricity Rules.

We have also harmonised our standards for disturbing loads by aligning with the national framework (clause 4.8 of the code). Harmonising the code with the national framework will provide clarity, consistency and simplicity for customers to comply with requirements to minimise disturbing loads on the grid.

Definition of a 'generating unit'

The code currently includes a definition of a 'generating unit' that is based on the common generation technology installed from more than a decade ago:[37]

generating unit means an electricity generator and related equipment essential to its operation, which together function as a single unit

Since then, the electricity network has seen the increased connection of other generation technologies, such as wind power or solar farms, that may not be captured by our existing definition of a 'generating unit'. Our current definition reflects the traditional synchronous-based units as the representative definition simply because there was no other technical alternative that was practical and economical. However, modern technology such as inverters for solar and batteries are changing this as they can both produce and absorb electricity.

[37] Electricity Distribution Code, version 9A, p41.

We have therefore updated the definition of a 'generating unit' to be technology neutral so that it can account for generation technologies such as solar photovoltaic and battery storage. Our definition aligns with the definition of a 'generating unit' under the National Electricity Rules. It should be noted that when this definition was recently updated in the national framework, stakeholders supported the updated definition for technology neutrality.[38] Stakeholders such as the Clean Energy Council supported this update with comments such as:

> "We (the Clean Energy Council) support the proposal to update the definition of a 'generating unit' to be technology neutral so that it can account for generation technologies such as solar PV and battery storage." [39]

Harmonising the register for distributed energy resources

The code currently requires distributors to maintain a register of embedded generators connecting to their network. Embedded generators include any generation facility such as small-scale solar photovoltaic generators, or larger combustion-based power generators.

On 1 December 2019, the Australian Energy Market Operator launched its national register of distributed energy resources. This register aims to capture necessary information on distributed energy resources connected to the grid to help support its management. The register also requires distributors to request relevant information from qualified electrical contractors and solar installers at the time of the installation of these devices or equipment.

To avoid unnecessary duplication, we have aligned our requirements for distributors to maintain a register of embedded generators with those of the recent national requirements (under the National Electricity Rules). We have amended clause 7.9 of the code to reflect the national register, and a consequential amendment to clause 9.1.3A of the code to rectify an incorrect reference to clause 7.8 (to clause 7.9).

[38] AEMC 2016, Rule determination: National Electricity Amendment (Registration of proponents of new types of generation) Rule 2016, 26 May 2016, p5.

[39] The Clean Energy Council, submission to the Essential Services Commission draft decision, p2, 17 January 2020

4. Other considerations to support grid management

There are other standards and requirements for distributors in the code that support the management of Victoria's electricity distribution system, including obligations on electricity distributors to report to us on their performance.

Reporting requirements for distributors on the use of smart meter technology and data

The code currently includes requirements on distributors to report annually on planned investments and upgrades on each of its networks through a report known as a Distribution System Planning Report (also known as the Distribution Annual Planning Report as per the national regulatory framework). This report also requires distributors to publicly identify network constraints to highlight potential opportunities for non-network solutions such as demand management and embedded generation.[40] We also recognise that these types of information have been visualised through a publicly available online map-based system.[41]

Following the summer outage of 2017–18, the Victorian Government conducted a review of the event. The review highlighted the need for distributors to improve the transparency and accessibility of information on network constraints, outage events and trends over time.[42] The review recommended that distributors make this information available on their websites in a timely manner.

We agree with the Victorian Government that publication of this network information should support the operation of the network and assist customers. We also recognise that certain kinds of information could help interested parties to identify potential commercial opportunities for distributors to consider as alternatives to traditional network upgrades.[43] We are also aware that distributors have produced interactive online maps on their websites that report on the outages occurring on their networks as close to real time as practical.

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[40] Electricity Distribution Code, clause 3.5

[41] Australian Renewable Energy Mapping Infrastructure, ARENA, https://nationalmap.gov.au/renewables/

[42] Post event review – Power outages 28 and 29 January 2018, Department of Environment, Land, Water and Planning, https://www.energy.vic.gov.au/safety-and-emergencies/past-energy-emergencies

[43] The National Electricity Rules have specific requirements as part of the demand management incentive scheme and demand management innovation allowance mechanism (National Electricity Rules, Schedule 5.8, clauses 6.6.3 and 6.6.3A).

To further these and other endeavours, we consider smart meter information could provide more granular information. Victoria is a leading jurisdiction in the deployment of smart meter technology, and this offers other opportunities for distributors to leverage their capabilities such as system performance monitoring.

Therefore, we have expanded the reporting requirements for distributors to report on how they are using the information from smart meter technology. We aim to provide further transparency for policy makers and industry on how distributors utilise smart meter technology to enhance the management and operation of the distribution system.

Final decision 5: introduce new obligations for distribution businesses to report on how they are using the information from smart meter technology

We have introduced new distributor reporting requirements on how smart meter technology and information is being used to enhance the management and operation of the distribution system. These changes aim to provide further transparency for policy makers and customers.

We have updated clause 3.5.1(e) of the code and introduced clause 3.5.3C, new definitions and schedule 1 to set out new reporting requirements for distributors.

We are particularly interested in requiring distributors to use smart meter technology and data to report on some key operational areas. We have updated the code to require that distributors in their annual Distribution System Planning Reports, include information on how smart meter technology is used to support:

- life support customers
- demand management initiatives and
- network reliability initiatives.

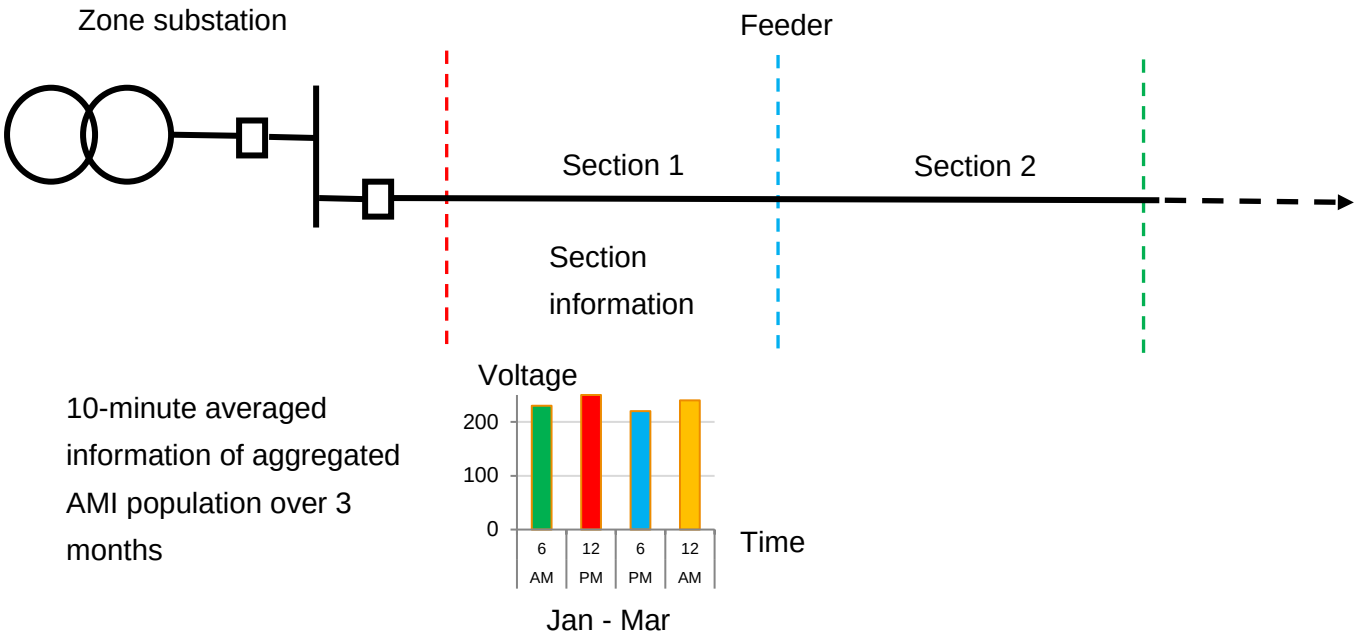
In our draft decision, we proposed a general obligation for distributors to provide information on these topics. However, stakeholder interest and feedback largely revolved around the reporting requirements for voltage performance. In other areas of reporting, there was limited feedback on what type of public information may be useful to stakeholders and the Victorian community. The final decision retains the general obligation for distributors to provide annual information on how smart meter technology is being used to enhance network operation.

Voltage performance reporting

Our final decision on voltage standards allows distributors some flexibility when designing and operating the grid for voltage management. Given this flexibility, we are also introducing obligations on distributors to report on voltage management as a means of transparency and accountability to customers.

We proposed in our draft decision a new obligation that distributors annually report on power quality performance of specific parts of the network, which is illustrated in Figure 4.

Figure 4 – Draft decision proposed voltage performance information concept illustration



Stakeholder feedback and relevant projects

To inform our final decision, we considered stakeholder feedback and other relevant projects and reports relating to the monitoring of voltage performance on electricity networks. In particular, we took into account the Australian Energy Regulator's considerations when assessing distributors expenditure to support distributed energy resources, which also recognised that there is limited visibility of the low voltage parts of distribution system. [44] This was also recognised by the Department of Environment, Land, Water and Planning.[45] We understand that distributors are considering investing further in its systems to improve monitoring of low voltage parts of the network. Other bodies such as the Australian Energy Market Commission is also exploring this space,[46] and the Australian Renewable Energy Agency supporting a range of projects on these matters.[47]

[44] Australian Energy Regulator - Assessing Distributed Energy Resources (DER) Integration Expenditure

[45] Department of Environment, Land, Water and Planning, submission to the Australian Energy Regulator – Assessing DER Integration Expenditure Consultation Paper, p2, 20 January 2020

[46] Australian Energy Market Commission – Priority area: Integration of distributed energy resources https://www.aemc.gov.au/our-work/our-forward-looking-work-program/integration-of-DER

[47] Australian Renewable Energy Agency https://arena.gov.au/

In response to our draft decision, stakeholders generally supported new obligations for distributors to report on voltage performance, with some stakeholders offering different approaches to reporting. The Clean Energy Council, Red and Lumo Energy and the Energy and Water Ombudsman of Victoria supported our proposed reporting format, stating:

> "The Clean Energy Council strongly supports the proposal to introduce new obligations for distribution businesses to report how they are using smart meter technology" [48]

> "Red and Lumo support the Commission's draft decision that requires distributors to report on how smart technology …we are pleased that the distributors will be required to provide more granular information regarding voltage standards on major feeders" [49]

> "We (The Energy and Water Ombudsman of Victoria) agree on principal that greater use of smart meter data could be made for the purpose of grid management" [50]

Distributors such as Citipower, Powercor and United Energy presented an alternative approach to the reporting make up, stating:

> "Alternatively, we (Citipower, Powercor and United Energy) suggest using logical electrical information such as grouping customers by distinct voltage control zone…" [51]

Ausnet Services stated another alternative:

> "We (Ausnet Services) believe possibly a better alternative would be to provide customers and stakeholders with more granular and customer specific information" [52]

We note that there is an existing provision of the code that requires distributors to provide individual customers with quality of supply information upon request. We consider that this existing provision alone is not sufficient to support the introduction of flexible voltage standard and provide transparency to customers.

With more than 99 per cent of households having smart meters installed, Victoria is in a leading position to use smart meter data to help manage the distribution network and provide timely data to customers. Smart meters are currently used to primarily provide accurate billing for individual

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[48] The Clean Energy Council, submission to the Essential Services Commission draft decision, p1, 17 January 2020

[49] Red and Lumo Energy, submission to the Essential Services Commission draft decision, p1-2, 20 January 2020

[50] The Energy and Water Ombudsman of Victoria, submission to the Essential Services Commission draft decision, p3, 20 January 2020

[51] Citipower, Powercor and United Energy, submission to the Essential Services Commission draft decision, p2, 17 January 2020

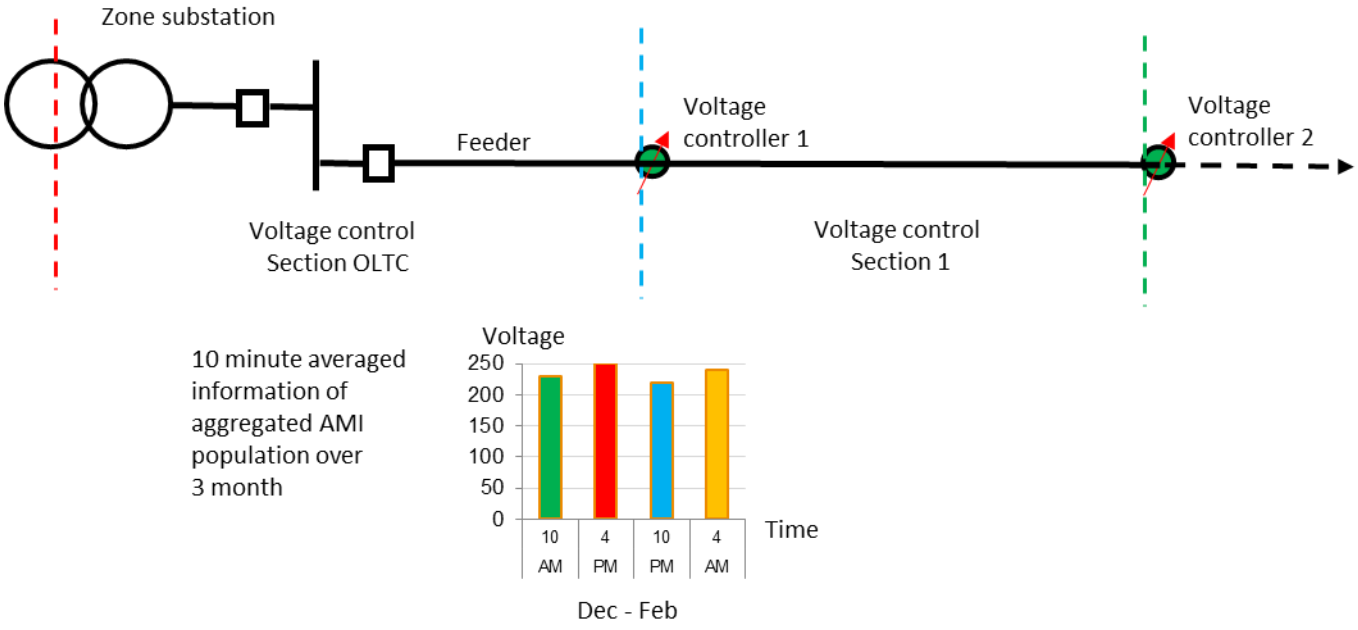
[52] Ausnet Services, submission to the Essential Services Commission draft decision, p1, 31 January 2020

customers electricity usage. But distributors are also increasingly looking for other ways to use smart meter data and features to provide information on network performance. For example, one approach would be aggregating individual smart meter data together to build a better picture of a small area of the network. We consider that making publicly available such aggregate data would promote transparency with the introduction of the flexible voltage standard. Such smart meter data could also encourage innovation in this space where other businesses could seek to leverage such information towards non-network solutions such as alternative local voltage support schemes.

The reporting measures as set out in this paper are considered some of the small, but initial steps towards a smarter grid. Distributors are seeking to invest in their information technology systems to leverage this further, and most distributors have sought funding approval in this area as part of their draft proposal to the Australian Energy Regulator. Subject to this process, distributors' capabilities in this space should be expected to increase over the coming years.

We have considered distributors' recent proposals to the AER in making our final decision on new reporting obligations. Our final decision amends the draft decision for distributors to report on voltage performance based on their current systems and available information. This is illustrated in Figure 5. We will review the extent of voltage performance reporting obligations as further investment and upgrades are made to distributor's systems.

Figure 5 – Final decision voltage performance information concept illustration



We are retaining key elements of our draft decision for the distributor reporting framework. However, based on currently available distributor information and capabilities, the final reporting requirements have been amended and summarised as follows:

Draft Decision	Final Decision
Feeder segmentation: • 10 even sections per feeder	Feeder segmentation: • 'Voltage Control' sections per feeder
Feeder reporting volume: • 3 samples consisting of the shortest, longest and nominated feeder	Feeder reporting volume: • All feeders
Time bands: • Day: 6am – 12pm, 12pm – 6pm • Night: 6pm – 12am, 12am – 6pm	Time bands: • Day: 10am – 4pm, 4pm – 10pm • Night: 10pm – 4am, 4am – 10am
Seasonal bands: • Jan – Mar, Apr – Jun • Jul – Sept, Oct – Dec	Seasonal bands: • Dec – Feb, Mar – May, • Jun – Aug, Sept – Nov
Data sampling methodology:	Data sampling methodology: • Distribution businesses to include an explanatory note on the methodology used for the 10-minute averaged data

For further clarity:

- **Feeder segmentation**: Amend the Ten even sections into 'voltage controlled' zones. This references the distributors zone substation On-Line Tap Changer (OLTC) as the key regulation device which manages voltage as well as any voltage regulators installed along the high voltage feeder as supplementary management device.
- **Feeder numbers**: The report now requires reporting on all feeders instead of the three samples of shortest, longest and nominated feeder.
- **Time bands**: Revised time bands to reflect how distributed energy resources may influence. This is based on available information from the Australian PV Institute Solar map information funded by the Australian Renewable Energy Agency.[53]

[53] Australian PV Institute, Solar and PV Maps and Tools, https://pv-map.apvi.org.au/

- **Seasonal bands**: Revised seasonal bands to reflect how distributed energy resources may influence. This is based on the Bureau of Meteorology average annual and monthly sunshine duration information.[54]
- **Data sampling methodology**: Distribution businesses may approach this slightly differently based on how they are employing the smart meter system. This has been introduced as a transparency measure.

Technical standards we are not changing

The following technical standards and requirements outlined in this section are not being updated. We consider these standards remain fit-for-purpose for the current operation of the network or may require further exploration to consider their effects. We note that many stakeholders did not comment or raise issues to our draft decision relating to many of the technical standards that are not being updated.

Final decision 6: other technical standards to remain unchanged

Based on our review and stakeholders largely not raising specific issues in their feedback, we are not making changes to some standards relating to minimum technical requirements for embedded generation, supply frequency, impulse voltage, load balance, fault level and REFCL condition time duration.

Minimum technical requirements for embedded generation

Some stakeholders raised in response to our issues paper for the code to prescribe common technical parameters to be defined for embedded generation technologies. These stakeholders were particularly concerned about standards relating to generator protection and control settings such as over and under voltage and frequency setpoints, rate of change of frequency and vector shift.[55]

We stated in our draft decision that it was inappropriate to prescribe technical parameters for embedded generators for the following reasons:

- For a basic type residential generator connection involving inverter-based technology (such as rooftop solar photovoltaic installations), the Australian Standard AS4777 already defines these

[54] Bureau of Meteorology, Average annual and monthly sunshine duration, http://www.bom.gov.au/

[55] Energy makeover and Onsite Energy, submissions to the Essential Services Commission issues paper, p5 respectively, 13 September 2019.

settings for the installation of the equipment ‘behind-the-meter’. As the code focuses on standards for the operation of the grid rather than private customer assets, we consider that the widespread application of AS4777 for behind-the-meter embedded generators is more appropriate to be part of the Australian Standard and not the code.

- For negotiated type generator connection, irrespective of the generation technology, we recognise that customers and distributors would negotiate optimal technical requirements that are tailored to that connection.
- The technical parameters being proposed for the code would also need to consider other factors such as those involving electricity safety. Furthermore, the operational and technical requirements for specific equipment or plant makes it impractical to implement in practice. For example, synchronous and inverter-based generation technologies have differing technical characteristics. To prescribe common protection and control settings would likely lead to incompatibilities with either of these generation technologies.

Stakeholders did not provide any further comments regarding our draft decision approach to this issue. We are therefore not prescribing any amendments to the code on this matter.

Supply frequency

Our August 2019 issues paper highlighted emerging new energy models such as micro-grids and stand-alone power system. Some of these models are designed to operate off-grid, or to disconnect under certain circumstances from the wider network to temporarily operate self-sufficiently. However, this means the management of technical matters such as frequency may reside with an entity other the Australian Energy Market Operator. This could be the operator of the micro-grid, stand-alone power system or another party.

Frequency

Supply frequency is an operating characteristic of the power system, and results from the physical spinning of electricity generators. The management of frequency is necessary for the safe, stable and secure delivery of electricity to customers. If frequency becomes too high or low, equipment connected to the network may stop working. In very unusual circumstances, unstable frequency could also lead to system wide instability and malfunctions.

Stakeholders had varying views on introducing new obligations in these areas. Some stakeholders proposed new requirements, while others suggested different reviews and projects as being more appropriate to consider frequency. We recognise this is a complex and emerging area, with a growing interest in these new operating models. We are also conscious of other ongoing research and pilot projects that might interact with our code requirements.

Our December 2019 draft decision proposed to explore these matters further as part of our intended wider review of the code in 2020. This will provide time to consider new information from

relevant research and the outcomes from trials underway, such as the microgrid demonstration projects currently being supported by the government.[56]

Impulse voltage

Stakeholders did not provide feedback to our draft decision approach on this matter. Therefore, our final decision retains the existing impulse voltage levels set out in the code. We consider that the current impulse voltage levels support the compliant operation of existing assets on the network. We also note the code does not prevent distributors and customers negotiating an arrangement that allows for impulse voltages to be at lower levels.

In August 2018, we made a final decision to change the voltage standards applicable for the 22kV distribution system. This was to enable the introduction and operation of bushfire mitigation technology known as REFCLs.

Since our final decision last year, some stakeholders commented on the impulse voltage rating (150kV) of the code being different from the latest equipment standards. We note that throughout the 2018 consultation process, the submissions received did not indicate this being a specific issue, also noting that Energy Safety Victoria also did not raise impulse voltage ratings as a concern.[57]

Our 2018 decision paper concluded that direct negotiation between distributors and customers allows for the most efficient solution to be agreed upon between both parties. It should also be noted that the code includes a clause that provides for negotiation between distributors and customers, allowing for conditions that are bilaterally agreed.[58] We consider this is more appropriate than network-wide standards set out in the code.

Some stakeholder submissions to our August 2019 issues paper suggested we consider a tiered approach to impulse voltage levels. This proposal sought the overhead distribution system retaining the existing 150kV level, and that underground assets would adopt a new lower impulse value of 125kV.[59] Another stakeholder proposed adopting a single reduced 125kV impulse level.[60]

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[56] Department of Environment, Land, Water and Planning, 2019, Microgrid Demonstration Initiative, available from: https://www.energy.vic.gov.au/microgrids

[57] Energy Safe Victoria submission: Electricity Distribution Code – Review of voltage standards for bushfire mitigation – draft decision, 12 June 2018, p7

[58] Electricity Distribution Code, Clause 1.6

[59] Citipower, Powercor, United Energy submission to the Essential Service Commission issues paper, p16, 13 September

[60] Middleton group submission to the Essential Service Commission issues paper, p1, 4 September 2019

Based on publicly available information, such as the Regulatory Information Notices published by the Australian Energy Regulator, we understand that most distribution assets are still predominantly of the overhead category. Furthermore, engineering solution such as surge arrestors could provide alternative mitigation measures for managing impulse voltage.[61] Given this, we consider that it is appropriate to retain the existing overhead impulse value of 150kV to cover most of the assets applicable for the Victorian distribution system. This should also clarify for distributors how they could approach any substantial network investments. We have, therefore, made no changes to the existing impulse levels of 150kV for the 22kV, 95kV for 11kV and 60kV for the 6.6kV systems.

It should also be noted that the code sets a maximum impulse voltage value. Where bespoke arrangements are required between customers and distributors, the code allows for both parties to negotiate appropriate solutions that may be below the 150kV impulse voltage level in the code.

Load balance

Load balance refers to those customers having a three-phase power supply that their equipment and systems should be balanced across these three phases.

The code provides for two approaches for load balance:

- negotiation to suit bespoke cases
- reasonable technical standards involving connections

We consider that these existing approaches would provide sufficient scope not to require amendment to these provisions.

Fault level

No specific matter was raised by stakeholders in this area. Therefore, we have not made any amendments or updates to this topic. With some communities showing a growing interest with new energy models, we will monitor this space to consider how technical matters such as fault levels may need to be considered into the future.

[61] Middleton group submission to the Essential Service Commission issues paper, p1, 4 September 2019

Rapid Earth Fault Current Limiter

In August 2018 we made our final decision to enable the operation of bushfire mitigation technology called Rapid Earth Fault Current Limiter (REFCL), particularly relating to voltage standards.[62] Given this decision was made less than two years ago, our recent draft decision did not propose any changes relating to REFCL operation. However, we received one stakeholder submission on matters related to voltage standards and REFCL operation as follows:

> "Victoria has placed no limit on the time a system is allowed to operate with a phase to earth fault, effectively ignoring over 100 years of European experience and the standards developed. The Victorian supply standard creates a situation where a standard solution cannot be guaranteed to survive on a REFCL network…" [63]

In response, we reflected on our 2018 final decision, as follows:

- **The new voltage standard (clause 4.2.2A) recognise the specific requirements of the Electricity Safety Act 1998.** When REFCL activates and for the duration it operates, the code provides for a temporary suspension of the phase to earth voltage limits. The framework under the Electricity Safety Act 1998 then takes effect, which includes the REFCL operating time duration. We also note that in response to this approach, the Australian Energy Regulator and Energy Safe Victoria expressed their support, respectively stating:

  > "Although the Commission has not adopted our proposed phase-to-earth voltage limits for REFCL operation, we recognise the superior merit of your alternative and support its adoption". [64]
  >
  > "This change is centred on Clause 4.2.2A and associated definitions…This allows good industry practice in accordance with recognised local and international engineering and safety standards to apply unhindered by regulation specific to Victoria… This change should be welcomed as logical, supportive of the Regulations, and consistent with international best practice…". [65]

- **Technical standards based in other jurisdictions.** We also considered a range of technical standards applied across international jurisdictions, including those in Europe and Asia, and particularly where REFCL technology were known to be operating. Our review found no

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[62] Essential Services Commission, Electricity Distribution Code – Review of voltage standards for bushfire mitigation – Final decision, 14 August 2018

[63] Charles Esson, submission to the Essential Services Commission draft decision, p1, 17 December 2019

[64] Australian Energy Regulator, submission to the Essential Services Commission, Electricity Distribution Code – Review of voltage standards for bushfire mitigation - draft decision, p1, 7 June 2018

[65] Energy Safe Victoria - Powerline Bushfire Safety Committee advice, submission to the Essential Services Commission, Electricity Distribution Code – Review of voltage standards for bushfire mitigation - draft decision, p3, 12 June 2018

identifiable and equivalent standards or regulatory provisions that prescribed an operating time duration for REFCL technologies. However, we did note some anecdotal information to suggest individual distributors may have set individual policies to suit local requirements.

- **Technical standards for equipment.** We also found inconsistencies with equipment standards regarding the time duration that REFCL would operate – some equipment standards indicated operating durations of 1 minute, others 8 hours, and some were not explicit with any time duration. We consider that the industry having discretion over operating timeframes would enable stakeholders to take a bespoke approach in how they could prepare for REFCL to suit their individual circumstances.

We also note that the relevant stakeholder submission focused on a specific asset category of voltage transformers, particularly those used for instrumentation and metering purposes involving control and protection schemes for high voltage supply arrangements. We understand that there was a small number of early REFCL that were installed before our 2018 final decision. As a result, distributors clarified and updated industry REFCL technical requirements for equipment like voltage transformers.[66] With the industry taking proactive measures towards complying with the requirements of the Electricity Safety Act 1998, we did not consider any new standards.

Our final decision is to make no changes to our 2018 final decision relating to voltage standards to support bushfire mitigation technology, and to continue enabling the requirements of the Electricity Safety Act 1998.

Other general updates

We have made other general updates for the code to reflect current legislation, regulations, referenced documents and definitions. For clarity, the updates to the latest references include:

- Australian Energy Market Operator documents to reflect the latest Single Industry Protocol for Electricity in Victoria
- the liability clause to reflect the Competition and Consumer Act 2010 and Australian Consumer Law (Victoria)
- definition of the ‘AER’ to reflect the Competition and Consumer Act 2010
- the five-minute interval settlement to reflect the National Electricity Rules change
- the definition of ‘electrician’ to reflect the Electricity Safety (Registration and Licensing) Regulations 2010
- the definition of a ‘meter' to harmonise with the metering code
- the Metrology Procedure to reflect Australian Energy Market Operator procedure

[66] Victorian Electricity Distributor Services and Installation Rules – 2014, p9-12,

- harmonising the definition of a ‘price determination’ with reference to the Australian Energy Regulator and
- harmonising the definition of a ‘regulatory test’ with reference to the Australian Energy Regulator.

5. Next steps

Commencement of new requirements

We will give effect to the code amendments on 3 April 2020.

Draft decision 7: commencement date of code amendments

We will give effect to the code amendments on 3 April 2020.

How to engage with us

General enquires

If you have other general enquires or wish to discuss with us about the code, you can contact us by:

Phone: (03) 9032 1300

Email: edc.review@esc.vic.gov.au

Website: https://www.esc.vic.gov.au/

Post: Attention: Energy division
Essential Services Commission
Level 37, 2 Lonsdale Street
Melbourne Vic 3000

Our approach to consultation is set out in our Stakeholder Engagement Framework.[67]

[67] Essential Services Commission, Stakeholder engagement framework – Charter of Consultation and Regulatory Practice, June 2018.

Abbreviations

Insert term	Insert definition
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
AMI	Advanced Metering Infrastructure
AS	Australian Standards
ESV	Energy Safe Victoria
IEC	International Electrotechnical Committee
IEEE	Institute of Electrical and Electronics Engineers
REFCL	Rapid Earth Fault Current Limiter
THD	Total Harmonic Distortion
TR	Technical Report

Appendix A – Our role and purpose of the code

Our role

The commission is Victoria's independent economic regulator. Our key objective is to promote the long-term interest of Victorian consumers with respect to the price, quality and reliability of essential services.[68]

Among other things, we are responsible for granting licences to anyone wishing to generate, transmit, distribute or retail electricity in Victoria. We may grant licences subject to any conditions we consider appropriate having regard to our objectives under the:

- Electricity Industry Act (2000) and the
- Essential Services Commission Act (2001).[69]

Licenced electricity distributors are required to comply with energy rules that we set out for them. These rules are set out in codes and guidelines and include (but are not limited to):

- Electricity Distribution Code (the code)
- Guideline 14: Electricity Industry – Provision of services by electricity distributors
- Guideline 15: Electricity Industry – Connection of Embedded Generation

In addition to state laws and our regulations, distributors are governed under the national regulatory framework. This framework is established under the National Electricity Legislation and the National Energy Rules. It generally differs from our remit by focusing on the economic regulation of the businesses and not on the non-economic regulatory matters (for example service standards and technical standards).

Purpose of the code

The purpose of the code is to set minimum service standards for the distribution network that tries to safeguard system security and provide a level of service protections for customers. Taking an extract of the code's introductory paragraph, it states:

The purpose of this Code is to regulate the following activities so that they are undertaken in a safe, efficient and reliable manner:

[68] Essential Services Commission Act (2001), section 8, (1), (2)

[69] Electricity Industry Act (2000), sections 19–20

(a) the distribution of electricity by a distributor for supply to its customers;

(b) the connection of a customer's electrical installation to the distribution system;

(c) the connection of embedded generating units to the distribution system; and

(d) the transfer of electricity between distribution systems.

The code has been in effect for many years setting out the service and technical standards distributors must deliver to customers. It was first written when the electricity distribution network was designed and operated under different circumstances. For example, the network was planned and designed for a system where a small number of large generators in specific locations supplied almost all of the electricity demand in Victoria. The network was then primarily focused on transmitting and distributing that power across the state.

The code provided technical parameters that the distributors had to meet. These were set to ensure network security, a reliable supply at a cost-effective level and set the minimum level of service the customers could expect to receive from the distributors.

Since then, the electricity industry has been rapidly changing, which has affected the way the network is maintained and operated. One such change is the introduction and uptake of technology that allows customers to have more control of their own electricity, such as solar panels and batteries. This means that the code may need to be updated to reflect what the network will need to do to ensure the code still delivers network security, customer protections and the service customers want.

What the code is not meant to do

It is also important to note that the code is not meant to be used as a means to promote or incentivise any particular technology. However, it is important that the code takes innovation into consideration and does not set any unnecessary barriers that prevent innovation while ensuring the system remains secure and customers are still afforded appropriate levels of protection.

Appendix B – Comparison of code voltage standards with Australian Standards (AS 60038)

Table 1

	Electricity Distribution Code		Australian Standards (AS 60038)	
	Voltage level (V)	Steady state operating range	Voltage level (V)	Steady state operating range
Low voltage	230	Table 1 (+10%, -6%)	230	Table 1 (+10%, -6%)
	400		400	
	460		460	
High voltage[70]	-	Table 1 (±6% urban) (±10% rural)	3,300	Table 3 (±10%)
	6,600		6,600	
	11,000		11,000	
	22,000		22,000	
	-		33,000	
	66,000	Table 1 (±10%)	66,000	Table 4 (no information)

Table 1 provides a comparison of nominal voltage standards between the code and the Australian Standard AS60038.

[70] High voltage is defined as exceeding 1,000V - Australian Standard 3000, 1.4.128, (c)

Appendix C – Comparison of low voltage standards across Australian jurisdictions

Table 2

Distribution network low voltage standards	
VIC	Electricity Distribution Code
NSW	AS 61000.3.100[71]
QLD	AS 61000.3.100[72]
SA	AS 61000.3.100[73]
TAS	AS 61000.3.100[74]
ACT	AS 61000.3.100[75]

Table 2 highlights the approach taken by some interstate distributors to manage their low voltage networks. In other cases, the jurisdictional regulator or Government department prescribes the standard.

[71] Services and Installation Rules of NSW, p17, Ausgrid (p167) and Essential Energy (p169), Distribution Annual Planning Reports

[72] Department of Energy and Water Supply Decision Regulatory Impact statement – Queensland's statutory voltage limits, 27 September 2017.

[73] South Australia Power Networks Distribution Annual Planning Report, p83

[74] Tasmania Electricity Code - Distribution System Operation, Chapter 8, p8-5

[75] Evo Energy, Annual Planning Report, p44

Appendix D – Comparison of power factor ranges across Australian jurisdictions

Victorian Electricity Distribution Code

Table 3

Power factor limits						
Supply Voltage in kV	Power factor range for customer maximum demand and voltage					
	Up to 100 kVA		Between 100 kVA - 2 MVA		Over 2 MVA	
	Minimum lagging	Minimum leading	Minimum lagging	Minimum leading	Minimum lagging	Minimum leading
< 6.6	0.75	0.8	0.8	0.8	0.85	0.85
6.6 11 22	0.8	0.8	0.85	0.85	0.9	0.9
66	0.85	0.85	0.9	0.9	0.95	0.98

Table 3 is the extract of the power factor range from our code. A customer must use best endeavours to keep their electrical installation power factor within the table 3 range under clause 4.3 of the code.

National Electricity Rules

Table 4

Power factor range	
Supply voltage	**Power factor range**
>400kV	0.98 lagging to unity
250kV - 400kV	0.96 lagging to unity
50kV – 250kV	0.96 lagging to unity
1kV – 50kV	0.9 lagging to 0.9 leading

Table 4 is a summary from the National Electricity Rule (v133) power factor requirements.

New South Wales

The NSW Services and Installation Rules state a customer must maintain the power factor not to be less than 0.9 lagging up to 50kV connection services.

South Australia

Table 5

Power factor limits						
Supply Voltage in kV	**Maximum Demand of electrical demand**					
	Up to 100 kVA		**Between 100 kVA - 2 MVA**		**Over 2 MVA**	
	Minimum Lagging	Minimum Leading	Minimum Lagging	Minimum Leading	Minimum Lagging	Minimum Leading
< 6.6	0.8	0.8	0.85	0.8	0.9	0.85
6.6 to 66	0.8	0.8	0.85	0.85	0.9	0.9

Table 5 is the power factor information available from the South Australia Power Networks Services and Installation Rules.

Queensland

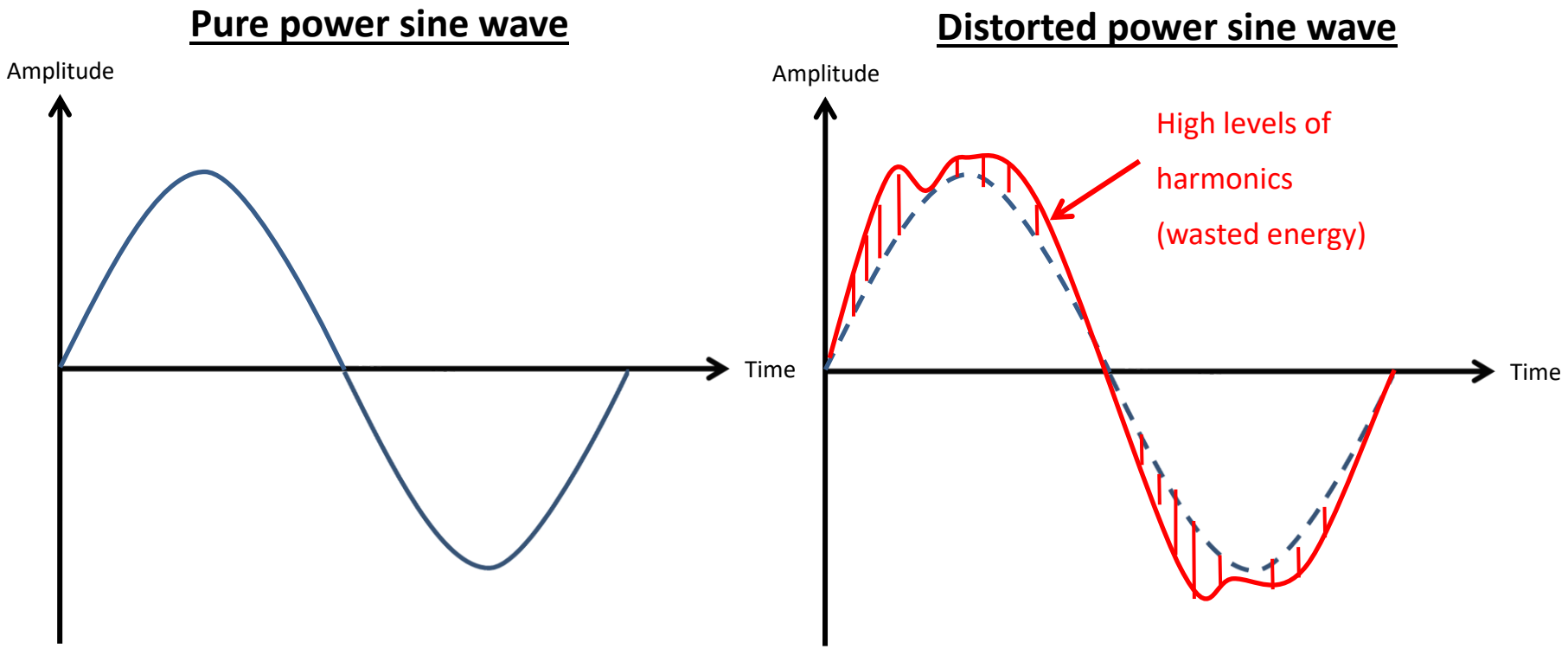
Table 6

Power factor performance	
Supply voltage	**Power factor range**
50kV – 250kV	0.95 to unity
1kV – 50kV	0.9 lagging to 0.9 leading
Less than 1kV	Above 0.8 lagging but not leading

Table 6 is the power factor information available from the Energex Services and Installation Rule

Appendix E – Comparison of harmonic limits with the National Electricity Rules

Figure A – Harmonics concept



Victorian Electricity Distribution Code

Table 7

Voltage harmonic distortion limits			
Voltage at point of common coupling	**Total harmonic distortion**	**Individual voltage harmonics**	
		Odd	**Even**
< 1 kV	5%	4%	2%
> 1 kV and ≤ 66 kV	3%	2%	1%

Table 7 is the voltage harmonic limits Victorian distributors are required to manage under clause 4.4.1 of the code.

Table 8

Current harmonic distortion limits						
Isc/IL	**Maximum harmonic current distortion in per cent of I_L**					
	Individual Harmonic Order "h" (Odd Harmonics)					**Total Harmonic Distortion**
	<11	**11 ≤ h <17**	**17 ≤ h < 23**	**23≤ h < 35**	**35 ≤ h**	
<20*	4.0%	2.0%	1.5%	0.6%	0.3%	5.0%
20<50	7.0%	3.5%	2.5%	1.0%	0.5%	8.0%
50<100	10.0%	4.5%	4.0%	1.5%	0.7%	12.0%
100<1000	12.0%	5.5%	5.0%	2.0%	1.0%	15.0%
>1000	15.0%	7.0%	6.0%	2.5%	1.4%	20.0%

Table 8 is the current harmonic limits Victorian customers are required to manage under clause 4.4.3 of the code.

National Electricity Rules

Table 9

Voltage harmonic distortion limits			
Voltage at point of common coupling	**Total harmonic distortion**	**Individual voltage harmonics**	
		Odd	**Even**
< 1kV	8%[76]	5% to 6%	2%
> 1kV and ≤ 35kV	6.5%[77]	5% to 6%	2%
> 35kV and ≤ 230kV	3%[45A]	2% to 5%	1.5%

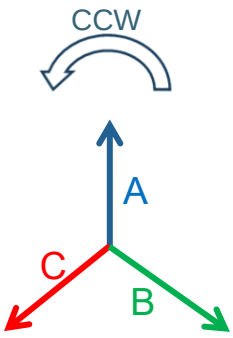
Table 9 is the table 1 and 2 values from AS61000.3.6-2001 prescribed under the National Electricity Rules, Schedule S5.1a.6.

[76] Australian Standard, AS61000.3.6, Compatibility level

[77 & 45A] ibid, Planning level

Appendix F – Comparison of negative sequence standards with the National Electricity Rules

Figure B – Negative sequence concept

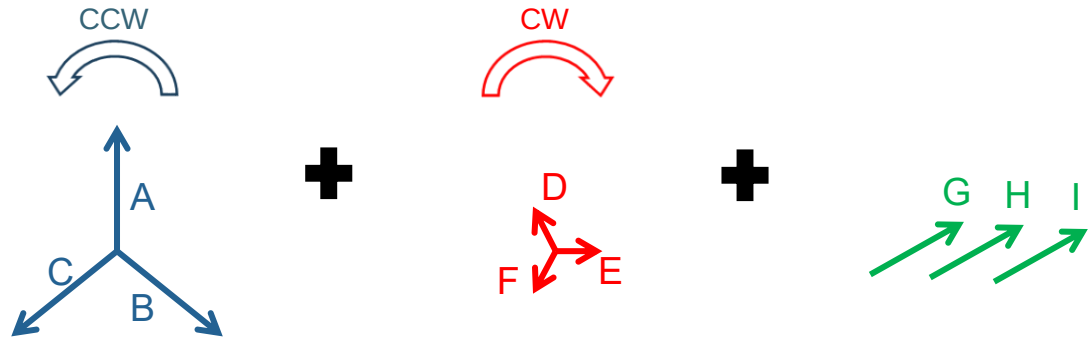


Positive sequence

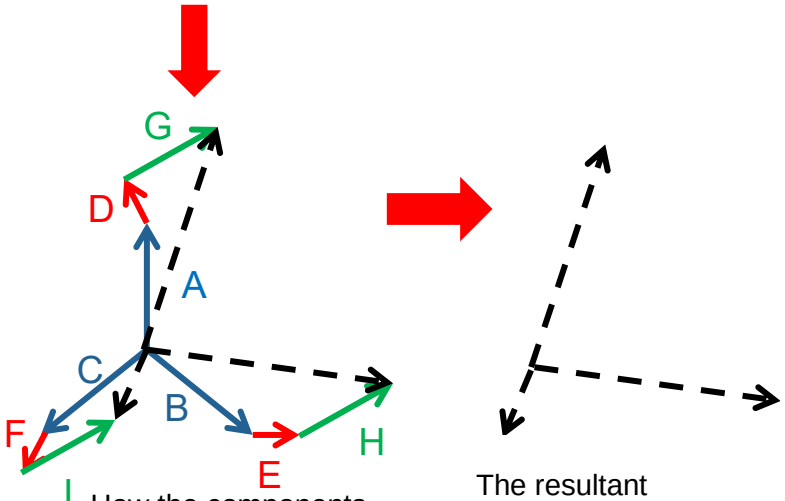
Balanced

Under ideal normal operation, the three-phase power system voltage would be balanced and rotating normally with no other components being present. In the engineering analytical method, this normal rotation is called the positive sequence (rotating counter-clockwise – CCW, in this case).

Unbalanced



Positive sequence | **Negative sequence** | Zero sequence



How the components add together

The resultant unbalanced voltage

Due to a range of factors, the power system could experience a level of imbalance even during normal operation. When this occurs, components such as negative sequence can be detected in addition to positive sequence. The above unbalanced diagram illustrates these components individually.

The left illustrates what the total summated unbalanced system may look like when added together (by connecting the same coloured arrows back to back). The dashed black represents the resultant unbalanced system.

Note: Accentuated diagram to illustrate concept

Electricity Distribution Code

Table 10

Negative sequence		
Voltage	**Duration**	**Maximum negative sequence (% of nominal voltage)**
All voltage levels	Steady state	1%
	5 minute every 30 minute	2%

Table 10 is a summary of the code, clause 4.6.

National Electricity Rules

Table 11

Negative sequence			
Voltage	**Duration**	**Maximum negative sequence (% of nominal voltage)**	**Note**
10kV to 100kV	30-minute average	1.3%	Non-contingent Credible contingent and protected
	10-minute average	2%	General
	1-minute average	2.5%	Once per hour
Up 10kV	30-minute average	2%	Non-contingent Credible contingent and protected
	10-minute average	2.5%	General
	1-minute average	3%	Once per hour

Table 11 is a summary of the National Electricity Rules Table S5.1a.1.

Appendix G – Maximum fault level of the code

Electricity Distribution Code

Table 12

Distribution system fault levels		
Voltage Level kV	**System Fault Level MVA**	**Short Circuit Level kA**
66	2500	21.9
22	500	13.1[78]
11	350	18.4
6.6	250	21.9
<1	36	50.0

Table 12 is the extract of the maximum fault level limits that embedded generators must not contribute to exceed under clause 7.8 of the code.

[78] The National Electricity Rules jurisdictional derogation provisions for the declared shared network with different fault level for certain parts of the Victorian 22kV network.