Future Security and Resilience – Review of common quality requirements in the Code

Suite of three consultation papers

25 June 2024

ELECTRICITY AUTHORITY
TE MANA HIKO

Executive summary

This paper provides an overview of, and context for, a suite of three consultation papers published by the Electricity Authority Te Mana Hiko (Authority) on matters related to common quality. 'Common quality' means those elements of the quality of electricity conveyed across New Zealand's power system that cannot be technically or commercially isolated to an identifiable person or group of persons. The common quality requirements in the Electricity Industry Participation Code 2010 (Code) are foundational to the safe and reliable supply of electricity to consumers.

Ensuring the future security and resilience of New Zealand's power system requires regulatory certainty through fit-for-purpose rules that are easy to access and understand. While this suite of papers addresses some of the more technical aspects of the power system, the content is critical to providing a solid regulatory foundation necessary to unlock the potential of our future power system and deliver better outcomes for consumers.

These papers are part of the Authority's review of the common quality requirements in Part 8 of the Code. This review forms part of our Future Security and Resilience (FSR) work programme.

Consultation papers

The consultation papers relate to five key common quality issues the Authority has identified:

- **Paper 1: Addressing more frequency variability in New Zealand's power system**

  This paper describes some options the Authority is proposing to investigate further to help address a key frequency-related issue with the common quality requirements in Part 8 of the Code.

- **Paper 2: Addressing larger voltage deviations and network performance issues in New Zealand's power system**

  This paper describes some options the Authority is proposing to investigate further to help address three key voltage-related issues with the common quality requirements in Part 8 of the Code.

- **Paper 3: The governance and management of harmonics in New Zealand's power system**

  This paper describes the Authority's thinking on the governance and management of harmonics, which have been identified as another key common quality issue. No options for investigation are proposed in this paper.

Addressing common quality issues aligns with our statutory objectives

Addressing these issues in a timely manner is consistent with our statutory objectives. The Authority wants the Code's common quality requirements to enable evolving technologies, particularly inverter-based resources. Examples of inverter-based resources include battery energy storage systems, solar photovoltaic generation, and wind generation.

We see these technologies as a key enabler of:

(a) consumers having more choice and flexibility around their electricity use and supply

(b) the electrification of parts of New Zealand's economy, such as transportation and heating.

In addition to providing opportunities, these technologies do, however, pose some challenges. In particular, we expect that co-ordinating the real-time operation of New Zealand's power system to supply electricity to consumers at the level of reliability they want will become more difficult over the coming years. This increased difficulty will be the result of evolving technologies enabling a significant increase in variable and intermittent generation and an increase in bi-directional electricity flows.

We want to address the key identified common quality issues in a manner that promotes reliability of electricity supply for consumers. We also want to address these issues in a way that promotes competition in, and the efficient operation of, the electricity industry. We see this as critical to promoting innovation in affordable electricity-related services.

Options to help address the frequency-related issue

The Authority has settled on a short list of three options we consider should be investigated further to help address the key frequency-related issue that has been identified:

(a) Option 1: Lower the 30MW threshold for generating stations to be excluded by default from complying with the frequency-related asset owner performance obligations and technical codes in Part 8 of the Code.

(b) Option 2: Set a permitted dead band beyond which a generating station must contribute to frequency keeping and instantaneous reserve.

(c) Option 3: Procure more frequency keeping to manage frequency within the normal band (49.8–50.2Hz), and procure more instantaneous reserve to keep frequency above 48Hz for contingent events and above 47Hz (in the North Island) and 45Hz (in the South Island) for extended contingent events.

Options to help address the voltage-related issues

The Authority has settled on a short list of three options we consider should be investigated further to help address the three key voltage-related issues that have been identified:

(a) Option 1: Assign voltage support obligations to some additional parties.

(b) Option 2: Manage the import and export of reactive power at a grid exit point.

(c) Option 3: Lower the 30MW threshold for generating stations to be excluded by default from complying with the fault ride through asset owner performance obligations in clauses 8.25A and 8.25B of the Code.

Other options are being progressed / will be looked at

The Authority wishes to highlight that we are considering other options to help address the key frequency- and voltage-related issues listed above. These options are part of other work programme initiatives underway, or planned to be underway, in the Authority.

Initially the Authority is deliberately focussing on options with a shorter Code development timeframe. However, we are not forgetting about options that would require a longer period to develop and implement in the Code. We will turn our focus to these as soon as time and resources permit.

It is too soon to consult on options to help manage harmonics

The Authority considers it is too soon to consult on a short list of options to be investigated further to help address the key harmonics-related issue that has been identified.

First, we want to consult with interested parties on our current thinking on the governance and management of harmonics. The management of harmonics receives relatively little attention in the Code and in other regulatory instruments. Fewer people in the electricity industry are familiar with harmonics compared to frequency and voltage.

We consider a better outcome will be achieved for consumers and industry participants if we describe what we see as the important elements of managing harmonics. Doing this will help facilitate 'everyone being on the same page' before we discuss options to help address the identified issue.

We are progressing Code amendments to help address two other key issues

The Authority has decided to progress with proposed Code amendments to help address the two remaining key common quality issues identified:

(a) Network operators have insufficient information on assets wanting to connect, or which are connected, to the power system to provide for the planning and operation of the power system in a safe, reliable, and economically efficient manner.

(b) The Code is missing some terms that would help enable technologies, and contains some terms that appear to not be fit for the purpose of appropriately enabling technologies.

We consider preferred options to help address these issues are more readily identifiable than for the first five issues.

The Authority plans to consult with interested parties on proposed Code amendments to help address these two issues in late 2024.

Your feedback on the suite of three consultation papers is welcomed

The Authority welcomes feedback from interested parties on:

(a) the short listed options to help address the frequency- and voltage-related issues

(b) our current thinking on the governance and management of harmonics on the New Zealand power system.

The Authority acknowledges the content of the three consultation papers is technical and has allowed for an 8-week consultation period. During the consultation period the Authority will be available to hold individual and group briefings with interested stakeholders. We will also look to hold webinars for the wider community of stakeholders.

Next steps beyond this consultation

Following this consultation, the Authority will decide which frequency- and voltage-related options will be investigated further for the purpose of proposing amendments to the Code. We will also prepare a consultation paper on short listed options to help address the identified harmonics issue.

We plan to share our decisions and supporting rationale in the form of a decision paper. We anticipate this will be published either in late 2024 or early 2025.

Contents

1. What you need to know to make a submission

What this consultation is about

1.1. The Authority is consulting with interested parties on:

(a) options we propose investigating further to help address key frequency-related and voltage-related issues with the common quality requirements in Part 8 of the Electricity Industry Participation Code 2010 (Code)

(b) the Authority's thinking on the governance and management of harmonics, which have been identified as another key common quality issue.

How and when to make a submission on the three consultation papers

1.2. The suite of three consultation papers are available on the Authority's website at:

(a) Paper 1: Addressing more frequency variability in New Zealand's power system: https://www.ea.govt.nz/documents/cqrconsultationpaper1

(b) Paper 2: Addressing larger voltage deviations and network performance issues in New Zealand's power system: https://www.ea.govt.nz/documents/cqrconsultationpaper2

(c) Paper 3: The governance and management of harmonics in New Zealand's power system: https://www.ea.govt.nz/documents/cqrconsultationpaper3

1.3. Each consultation paper explains how to make a submission to the Authority on that paper.

1.4. Submissions are due to the Authority by 5pm on Tuesday 20 August 2024.

2. Background

The Future Security and Resilience programme

2.1. The Authority's Future Security and Resilience (FSR) programme is a multi-year work programme that seeks to ensure New Zealand's power system remains secure and resilient as the country transitions towards a low-emissions energy system. By 'power system' we mean all components of the New Zealand electricity system underpinning the New Zealand electricity market, including generation, transmission, distribution, and consumption (load) assets.

'Security', 'Resilience' and 'Reliability'

'Security' refers to the ability of the power system to withstand adverse events, ensuring a steady and stable network that delivers generation to where it is needed (ie, significant adverse events do not cause electricity outages).

'Resilience' refers to the ability to identify and mitigate high-impact low-frequency threats to the power system quickly and efficiently, to minimise damage to infrastructure and support services, while enabling a quick recovery and restoration of the power system to a stable operating state.

'Reliability' refers to both the continuity of electricity supply (ie, the rate and duration of electricity outages, including because of insufficient fuel for electricity generation), and the quality of electricity supply (eg, the frequency and voltage of electricity).

2.2. Electrifying certain sectors, such as transport and industrial processes, is important to New Zealand meeting its 2050 net zero carbon target. The electricity system needs to both enable and respond to this electrification and resulting increase in electricity demand. A critical challenge is to ensure reliability of supply during the transition, at least cost to consumers.

2.3. The Authority considers evolving technologies, particularly inverter-based resources, are a key enabler of electrification. Examples of inverter-based resources include battery energy storage systems, solar photovoltaic generation, and wind generation.

2.4. These technologies will enable consumers to have more choice and control around their electricity use and supply.

2.5. However, the uptake in these technologies will lead to a significant increase in variable and intermittent generation, and an increase in bi-directional electricity flows. These will pose challenges to the co-ordination of New Zealand's power system.

2.6. This is where the FSR programme applies.[1] The Authority wants to address these challenges to promote a reliable electricity supply for consumers. We also want to address these challenges in a way that promotes competition in, and the efficient operation of, the electricity industry. We see this as critical to promoting innovation in affordable electricity-related services.

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[1] See Electricity Authority | Future Security and Resilience.

2.7. The Authority wishes to highlight that the FSR programme is focussed on how the power system operates in real time, or close to real time, to balance electricity supply and demand continuously and to supply consumers with electricity that is of an appropriate quality.

2.8. The FSR programme is not evaluating the power system's ability to ensure electricity supply is able to meet electricity demand over periods longer than a few days (often referred to as 'energy adequacy'). The Authority has other programmes of work considering this, such as:

(a) the 'Pricing in a renewables-based electricity system' project, which is focussed on the necessary changes to the wholesale electricity market in a world of 100% renewable supply, to ensure there are economically efficient price signals (from short term to long term) that are consistent with the Authority's statutory objectives[2]

(b) the Authority's work to support the electricity system to better co-ordinate resources during peak demand periods.[3]

'FSR indicators' help inform FSR work programme prioritisation

2.9. The Authority has published a dashboard of 'FSR indicators' on our website to monitor changes to the opportunities and challenges to future security and resilience.[4] These indicators are designed to be a low-cost and simple way to help inform decisions about whether changes should be made to the prioritisation of FSR programme activities in light of new information.

2.10. The Authority updates the indicators every six months to ensure they remain fit-for-purpose. We plan to add any new, more relevant FSR indicators as different data sources become available and/or FSR opportunities / challenges evolve over time.

Reviewing the common quality requirements in Part 8 of the Code

2.11. The highest priority activity in the FSR work programme is a review of the common quality requirements in Part 8 of the Code. The review's purpose is to ensure these requirements enable evolving technologies, particularly inverter-based resources, in a manner that is consistent with the Authority's statutory objectives.

2.12. This review is the highest priority activity on the FSR work programme because of:

(a) the need to ensure the common quality requirements accommodate and facilitate the opportunities offered by evolving technologies, particularly inverter-based resources

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2 The Authority's main statutory objective is to promote competition in, reliable supply by, and the efficient operation of, the electricity industry for the long-term benefit of consumers. The Authority's additional objective is to protect the interests of domestic consumers and small business consumers in relation to the supply of electricity to those consumers. The additional objective applies only to the Authority's activities in relation to the dealings of industry participants with domestic consumers and small business consumers.

3 See Electricity Authority I Managing peak electricity demand.

4 See Electricity Authority I Future security and resilience indicators.

(b) the increasing risk to security and resilience as more distributed generation is installed and bi-directional electricity flows become more prevalent

(c) the increasing risk of investments in evolving technologies bringing about outcomes that are not for the long-term benefit of consumers.

2.13. As Figure 1 and Figure 2 show, the power system is changing. We need to ensure the common quality requirements in Part 8 of the Code are fit-for-purpose now and in the future.

Figure 1: The power system of the past

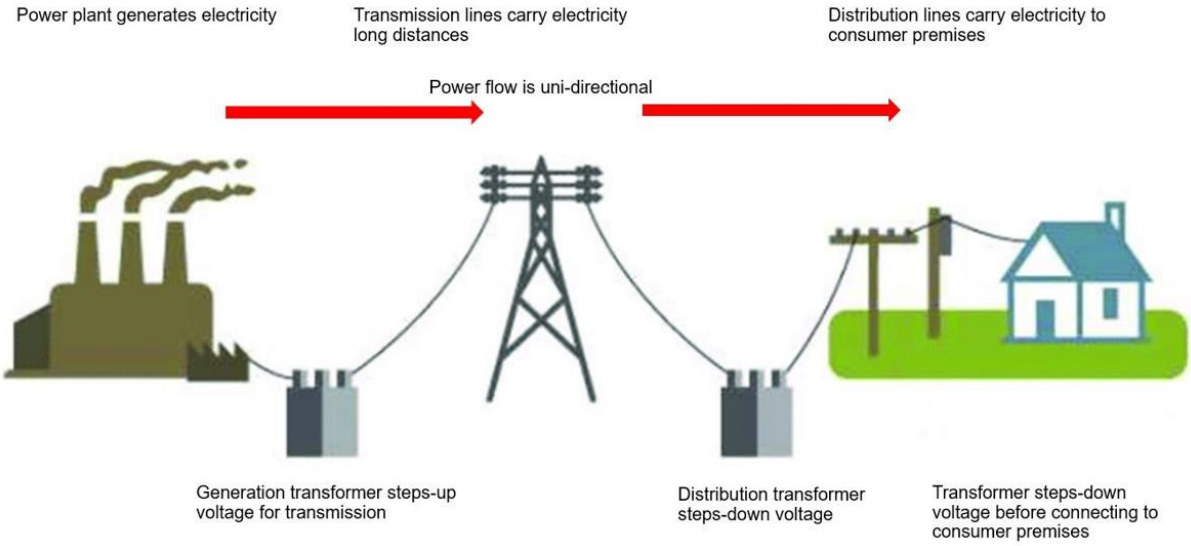
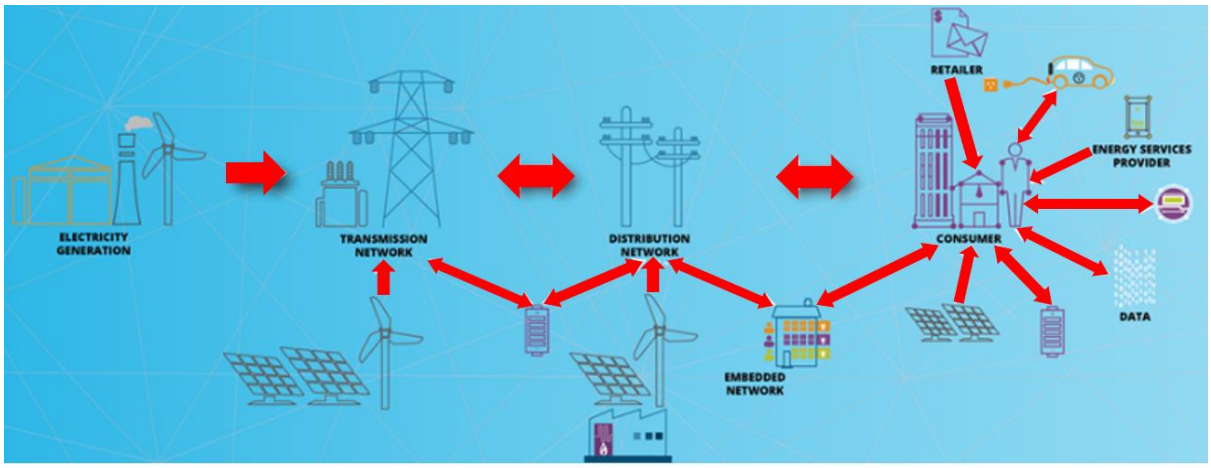


Figure 2: The power system today



Power flows have become bi-directional with distributed energy resources (DER) connecting to the distribution network

2.14. These changes to the power system are also an important driver of the 'Future System Operation' workstream within the FSR programme. This workstream is looking at the potential challenges and opportunities with operating the power system as New Zealand transitions to a low-emissions economy.[5]

[5] See Electricity Authority | Future operation of New Zealand's power system.

2.15. For the purposes of the review of common quality requirements in the Code, the Authority is defining common quality to apply across all of New Zealand's connected transmission and distribution networks. This is broader than the Code's definition, which defines 'common quality' as relating only to the transmission network. The broader definition being used in the FSR programme acknowledges that various security and resilience challenges and opportunities will be common to the transmission network and distribution networks.

What is 'common quality'?

'Common quality' means those elements of the quality of electricity conveyed across New Zealand's power system that cannot be technically or commercially isolated to an identifiable person or group of persons. An example is the frequency of electricity.

2.16. While the focus of this work is on the common quality requirements in Part 8 of the Code, the Authority is aware that a review of these requirements has linkages to one or more other parts of the Code. The Authority is carefully considering these linkages as part of the review of the common quality requirements in Part 8.

The Authority is taking a first-principles approach

2.17. The Authority is adopting a first-principles approach to reviewing the extent to which the Code's common quality requirements appropriately enable technologies. That is, the Authority is looking at the fundamental reasons for placing common quality Code obligations on existing and evolving technologies. This is to ensure, as far as practicable, that underlying issues are identified, rather than symptoms or exacerbators of issues.

2.18. Taking a first-principles approach to identifying common quality issues should result in a more complete and coherent set of common quality Code requirements that enable technologies in a manner that promotes the Authority's statutory objectives.

2.19. The Authority notes it is *not undertaking* a first principles review of Part 8 of the Code in its entirety as part of the FSR programme. Part 8 requirements that do not relate to common quality are outside the scope of this work.

Through stakeholder engagement we have identified seven key issues

2.20. Through a combination of one-on-one engagement[6] and formal consultation[7] with interested parties, the Authority has identified seven key issues with the common quality requirements in Part 8 of the Code. The identified issues are:

(a) Issue 1: An increasing amount of variable and intermittent resources, primarily in the form of wind and solar photovoltaic generation, is likely to cause more

6 Including with the system operator, distributors, generators, retailers, industry representative bodies, and Transpower as a transmission network owner.

7 See our 2023 consultation paper *Future Security and Resilience - Review of common quality requirements in Part 8 of the Code – Issues Paper*.

variability in frequency within the 'normal band' of 49.8–50.2 Hertz (Hz), which is likely to be exacerbated over time by decreasing system inertia.

(b) Issue 2: An increasing amount of variable and intermittent resources, primarily in the form of wind and solar photovoltaic generation, is likely to cause larger voltage deviations, which are exacerbated by changing patterns of reactive power flows.

(c) Issue 3: Increasing amounts of inverter-based variable and intermittent resources will reduce the transmission network's system strength thereby increasing the likelihood of network performance issues if inverter-based resources disconnect from the power system.

(d) Issue 4: Over time increasingly less generation capacity is expected to be subject to fault ride through obligations in the Code, as more generating stations export less than 30MW to a network.

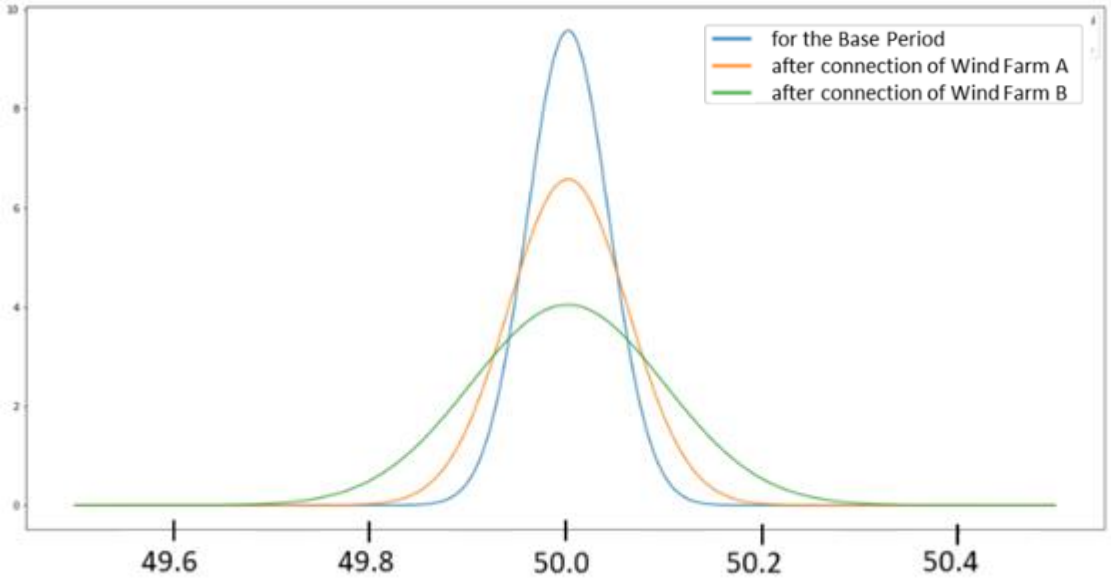
(e) Issue 5: There is some ambiguity around the applicability of harmonics standards and who manages harmonics (including the allocation of harmonics).

(f) Issue 6: Network operators have insufficient information on assets wanting to connect, or which are connected, to the power system to provide for the planning and operation of the power system in a safe, reliable, and economically efficient manner.

(g) Issue 7: The Code is missing some terms that would help enable technologies, and contains some terms that appear to not be fit for the purpose of appropriately enabling technologies.

2.21. Figure 3 provides a graphical representation of Issue 1. The increase in the standard deviation in Figure 3 shows higher variability of frequency within the normal band following the commissioning of the two wind farms.

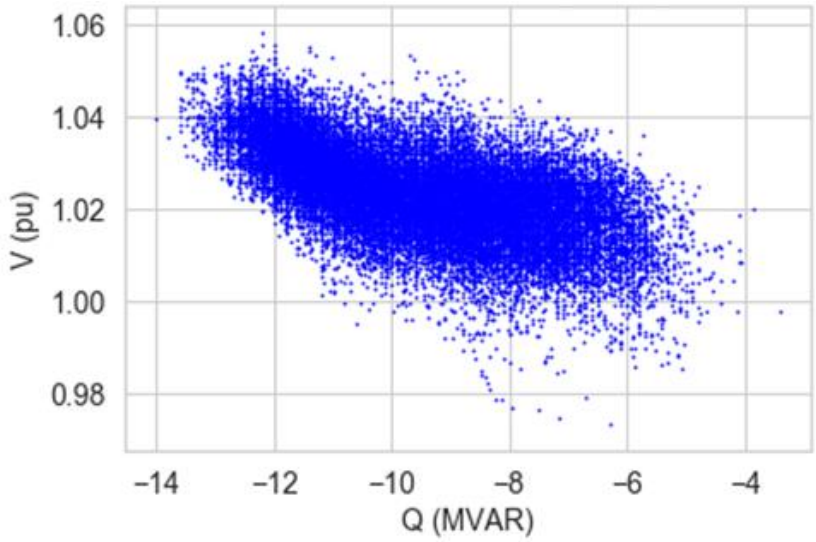
Figure 3: Frequency quality pre- and post-commissioning of two wind farms



Source: System operator

2.22. Figure 4 provides a graphical representation of how changing patterns of reactive power flows can exacerbate voltage deviations (Issue 2). In this example, increasing reactive power flows from the distribution network to the transmission network at the Kopu grid exit point (shown on the horizontal axis) causes voltage at the grid exit point to rise (shown on the vertical axis).

Figure 4: Voltage and reactive power at the Kopu grid exit point[8]

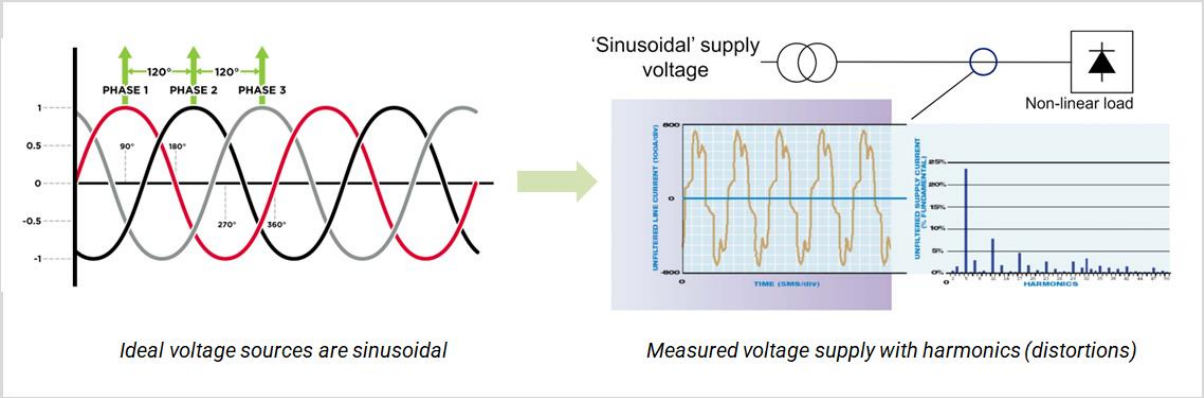


Source: System operator

Notes: The negative values on the horizontal axis represent reactive power flows from the distribution network to the transmission network.

2.23. Figure 5 provides a graphical representation of the effect of harmonics on the quality of electricity (Issue 5). Harmonics cause distortion of the fundamental 50Hz current and voltage sinusoidal waveforms. This distortion is not limited to one cycle of a waveform, but rather occurs across adjacent cycles of a waveform.

Figure 5: The effect of harmonics on the quality of electricity



Source: Electricity Authority

[8] Specifically, at the Kopu grid exit point bus bar: 'KPU_110 kV_AV'.

'Inverters' and 'Inverter-Based Resources'

An 'inverter' is an electronic device that converts direct current (DC) electricity to alternating current (AC) electricity. Electronic devices that convert AC electricity to DC electricity are known as 'rectifiers'.

An 'inverter-based resource' is equipment that uses an inverter when functioning. Examples include wind generation, solar photovoltaic generation and battery energy storage systems.

2.24. Since receiving feedback on our draft list of common quality issues, the Authority has considered a range of options to help address the frequency-related and voltage-related problems listed above. We have also considered how the governance and management of harmonics on New Zealand's power system might be improved.

2.25. The Authority has benefitted greatly from the input we have received from the Common Quality Technical Group and the system operator. The Common Quality Technical Group is supporting our evaluation of options to help address the common quality issues identified. The knowledge and experience of its members collectively ranges from the operation of the power system at both the transmission and distribution levels to the operation of generation and demand-side management technologies.[9] The insights provided by people with day-to-day operational involvement in common quality matters and/or who bring a range of relevant commercial and technical experience has been most valuable to us.

The Common Quality Technical Group

The Common Quality Technical Group is a technical group supporting the Authority's evaluation of options to help address the common quality issues identified as part of the review of the common quality requirements in Part 8 of the Code.

The Common Quality Technical Group provides a forum for persons with different expertise and experience relevant to the review of the Code's common quality requirements to share their knowledge with the Authority and with each other.

The knowledge and experience of Common Quality Technical Group members collectively ranges from the operation of the power system at both the transmission and distribution levels to the operation of generation and demand-side management technologies.

We want to address these issues in a timely manner

2.26. The Authority is now at a point where we want to share with interested parties some short listed options to help address the frequency and voltage issues. We also want to share with interested parties our current thinking on how the governance and management of harmonics on the power system might be improved.

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9 Further information on the Common Quality Technical Group is available on the Authority's website at Common Quality Technical Group | Electricity Authority (ea.govt.nz).

2.27. Addressing these issues in a timely manner will help promote the reliable supply of electricity by the electricity industry, for the long-term benefit of consumers.

The need to address Issue 1 in a timely manner

2.28. If the frequency-related issue is not addressed in a timely manner, it will become more challenging for the system operator to continuously balance the demand for, and supply of, electricity conveyed across the power system. Maintaining frequency within a suitable range is important, in particular:

(a) to avoid equipment that produces or uses electricity being damaged and causing economic loss, and potentially physical harm

(b) to avoid cascade failure of the power system, caused by electrical equipment disconnecting from the power system in order to avoid damage, which again results in economic loss and potentially physical harm.

2.29. Not addressing the frequency-related issue in a timely manner may result in consumers being adversely affected by more frequency variability, to the extent their electrical equipment operates sub-optimally. This would be expected to impose economic costs on them. Consumers may also be adversely affected economically by the additional costs associated with the system operator managing system frequency (eg, procuring additional instantaneous reserve to cover less generator governor response on the power system).

The need to address Issues 2–4 in a timely manner

2.30. If the voltage-related issues are not addressed in a timely manner, it will become more challenging for the system operator and distributors to manage voltages across New Zealand's power system. Maintaining voltage within a suitable range is important:

(a) to enable active power, which consumers' electrical devices and equipment rely on to operate, to flow across the power system

(b) to avoid equipment that produces, conveys or uses electricity being damaged and causing economic loss, and potentially physical harm

(c) to avoid cascade failure of the power system, caused by electrical equipment disconnecting from the power system in order to avoid damage, which again results in economic loss and potentially physical harm.

2.31. Not addressing the voltage-related issues in a timely manner may result in consumers facing economic costs to the extent their electrical equipment operates sub-optimally or is damaged by greater voltage deviations or greater voltage instability.[10] Consumers may also face economic costs to the extent there are more power supply interruptions due to voltage events.

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[10] Over-voltage can damage insulation in electrical equipment, while under-voltage can cause excessive current to flow through electrical equipment.

2.32. Consumers may also be adversely affected economically by the additional costs associated with the system operator:

(a) operating a transmission network that has greater voltage deviations

(b) managing system voltage / system security.[11]

The need to address Issue 5 in a timely manner

2.33. If the harmonics issue is not addressed in a timely manner, then excessive levels of harmonics on parts of New Zealand's power system may occur. Excessive levels of harmonics:

(a) can cause problems for consumers' electrical equipment / appliances (eg, overheating, motor vibration, control equipment jitter, premature failure and, potentially, safety-related risks)

(b) lead to poor power quality—harmonics can adversely affect power quality both within the installation in which they are generated, and also within installations that share the same (electrically close) section of network (eg, the same substation)

(c) interfere with fixed line telecommunications—since the harmonic currents often oscillate at the same frequencies as the voice communications being transmitted over the phone line, causing interference.[12]

Not addressing the harmonics-related issue in a timely manner may result in consumers facing economic costs, to the extent their electrical equipment / appliances operate sub-optimally, or suffers damage / premature failure.

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[11] For example:

(a) procuring additional instantaneous reserve to cover a higher risk of generators disconnecting from the power system due to greater voltage deviations / instability or fewer generators remaining connected to the power system during faults on the power system

(b) constraining the dispatch of generation.

[12] Noting this is becoming progressively less of an issue with the ongoing change to fibre of New Zealand's telecommunication network cables.

3. The process followed to short list options for further investigation

3.1. Working with the Common Quality Technical Group and the system operator, the Authority is developing options to help address all seven key issues with the common quality requirements in Part 8 of the Code.

A set of evaluation criteria was developed

3.2. The first step in the process to develop options to help address these key common quality issues was to develop a set of evaluation criteria to assist us in prioritising options. We did this, drawing in particular on:

(a) the Code amendment principles in the Authority's consultation charter[13]

(b) the Market Development Advisory Group's recommended principles to guide the development of proposals for the FSR work programme[14]

(c) the Market Development Advisory Group's proposed principles to guide the design of Code arrangements for new generating technologies in the wholesale electricity market.[15]

3.3. The set of evaluation criteria are shown in Table 1.

Table 1: Evaluation criteria

Evaluation criteria	Elaboration
The option is feasible / implementable with little or no risk of unintended consequences	Feasibility / ease of implementation, and little or no risk of unintended consequences are important. Preference is given to options/solutions that are flexible, scalable and relatively easily reversible.
The option is consistent with the Authority's statutory objectives	The Authority's main statutory objective is to promote competition in, reliable supply by, and the efficient operation of, the electricity industry for the long-term benefit of consumers. The Authority's additional objective is to protect the interests of domestic consumers and small business consumers in relation to the supply of electricity to those consumers. The additional objective applies only to the Authority's activities in relation to the dealings of industry participants with domestic consumers and small business consumers.

13 See Electricity Authority | Consultation Charter 2024.

14 As the Market Development Advisory Group had not prepared recommended principles at the time, we used the proposed principles set out in its 6 December 2022 'Library of options' paper on price discovery in a renewables-based electricity system (see Electricity Authority | MDAG Library of options paper). However, we note the set of recommended principles aligns with the set of proposed principles (see Electricity Authority | MDAG Final recommendations report).

15 Market Development Advisory Group, June 2020, Enabling participation of new generating technologies in the wholesale electricity market – Market Development Advisory Group recommendation to Authority Board (see Electricity Authority | MDAG recommendations paper on enabling new generating technologies).

The option promotes competitive neutrality amongst technologies / fuels	The option / solution should be neutral as to which technology / fuel can provide the required service / output.
The option signals full costs and benefits	The option / solution should signal the full marginal costs and benefits to participants / consumers associated with alternative technologies / fuels providing the required service / output.
The option is output-based rather than prescriptive	If practicable the option / solution should specify outcomes required of industry participants.
The option is a market-based approach	Preference is given to market-based approaches to providing the required service / output, to promote innovation and transparency of the full costs and benefits of an option / solution.
The option is durable	The option / solution should be durable across a range of uncertain future scenarios.

A 'long list' of options was developed

3.4. Following our consideration of submitters' feedback on the April 2023 issues paper, the Authority confirmed with the Common Quality Technical Group that all the key issues with the common quality requirements in Part 8 of the Code were contained within the seven identified key issues.

3.5. Working with the system operator the Authority compiled a draft 'long list' of 33 options to help address the seven key issues. We tested this draft long list with the Common Quality Technical Group. This resulted in a further 10 options being added to the long list.

The long list of options was evaluated against the first evaluation criterion

3.6. Working with the system operator, the Authority evaluated the long list of 44 options against the first of the seven evaluation criteria in Table 1— ie, the option is feasible / implementable with little or no risk of unintended consequences.

3.7. The Authority removed from the long list those options we considered feasible but:

(a) expensive or which have a long implementation and/or a moderate risk of unintended consequences (>3 years to change the Code, >5 years to change assets, >$50m implementation cost)

(b) expensive and which have a long implementation and/or a significant risk of unintended consequences (>5 years to change the Code, >7 years to change assets, >$100m implementation cost).

3.8. The reason for this approach was to enable options that can deliver 'quick(er) wins' to be progressed ahead of options that require a longer gestation, and which are not necessarily needed within the next five years.

3.9. The Authority tested our evaluation of the long listed options with the Common Quality Technical Group, who agreed with our evaluation subject to options that had not made the medium list being revisited in 2024.

A ‘medium list’ of options was evaluated against the remaining evaluation criteria

3.10. The Authority retained in a ‘medium list’ the options we considered to be:

(a) strongly feasible with no risk of unintended consequences (<1 year to change the Code, <2 years to change assets, <$10m implementation cost)

(b) moderately feasible with low risk of unintended consequences (<2 years to change the Code, <3 years to change assets, <$20m implementation cost)

(c) feasible with uncertain risk of unintended consequences.

3.11. The Authority evaluated the options in the medium list against the remaining six evaluation criteria in Table 1.

A ‘short list’ of options was agreed

3.12. Following our evaluation of the medium list, the Authority developed a ‘short list’, which we agreed with the Common Quality Technical Group. The short list is shown in Table 2.

3.13. The main reason for options in the medium list not making the short list was because the Authority is considering them in other workstreams.

Table 2: Short list of options to help address the seven key common quality issues

Issue		Short listed option	
1.	An increasing amount of variable and intermittent resources, primarily in the form of wind and solar photovoltaic generation, is likely to cause more variability in frequency within the ‘normal band’ of 49.8–50.2Hz, which is likely to be exacerbated over time by decreasing system inertia.	1.	Lower the 30MW threshold for generating stations to be excluded by default from complying with the frequency-related asset owner performance obligations and technical codes in Part 8 of the Code.
		2.	Set a permitted dead band beyond which a generating station must contribute to frequency keeping and instantaneous reserve.
		3.	Procure more frequency keeping to manage frequency within the normal band (49.8–50.2Hz), and procure more instantaneous reserve to keep frequency above 48Hz for contingent events and above 47Hz (in the North Island) and 45Hz (in the South Island) for extended contingent events.

2. 3. 4.	An increasing amount of variable and intermittent resources, primarily in the form of wind and solar photovoltaic generation, is likely to cause larger voltage deviations, which are exacerbated by changing patterns of reactive power flows. Increasing amounts of inverter-based variable and intermittent resources will reduce the transmission network's system strength thereby increasing the likelihood of network performance issues if inverter-based resources disconnect from the power system. Over time increasingly less generation capacity is expected to be subject to fault ride through obligations in the Code, as more generating stations export less than 30MW to a network.	4. 5. 6.	Assign voltage support obligations to some additional parties. Manage the import and export of reactive power at a grid exit point. Lower the 30MW threshold for generating stations to be excluded by default from complying with the fault ride through asset owner performance obligations in clauses 8.25A and 8.25B of the Code.
5.	There is some ambiguity around the applicability of harmonics standards and who manages harmonics (including the allocation of harmonics).	7. 8.	Locate up-to-date standard(s) for harmonics in one piece of legislation / regulation (eg, the Electricity Industry (Safety) Regulations 2010 or the Code). Remove the first-mover advantage associated with total harmonic distortion by requiring the first-mover to give up some of their share of total harmonic distortion.

6.	Network operators have insufficient information on assets wanting to connect, or which are connected, to the power system to provide for the planning and operation of the power system in a safe, reliable, and economically efficient manner.	9. 10. 11.	Require wind generation to undertake periodic testing and provide results to the system operator and as appropriate distributors, so they can keep their models up to date. Lower the threshold for generating stations to provide real time operational data to the system operator and as appropriate to distributors. Require asset owners (grid-connected parties, grid owners, and embedded generators) to provide asset capability information that network operators and network owners require to meet their regulatory obligations. This includes asset owners providing network operators with sufficiently detailed information so that there is no 'black box' when the network operator comes to use the information for equipment performance assessment and checking compliance with technical requirements on the asset owner set out in the Code (eg, the system operator checking compliance with technical requirements in Part 8 of the Code).
7.	The Code is missing some terms that would help enable technologies, and contains some terms that appear to not be fit for the purpose of appropriately enabling technologies.	12.	Remove some technology-specific references. Make existing definitions fit for purpose and introduce new definitions.

Several power system studies have been undertaken to aid consideration

3.14. To aid our consideration of the frequency- and voltage-related short listed options, the Authority has engaged the system operator to undertake several power system studies.

3.15. The frequency-related studies may be summarised as follows:

(a) To investigate whether, with the expected uptake of inverter-based variable and intermittent generation over the coming years, the threshold for automatically excluding generating stations from the frequency-related asset owner performance obligations and technical codes should be amended.

(b) To assess how different dead bands within the normal band affect the amount of frequency keeping needed to maintain frequency within the normal band.

(c) To assess how different dead bands within the normal band affect the amount of instantaneous reserve needed to keep frequency above 48Hz during a contingent event.

3.16. The voltage-related studies may be summarised as follows:

(a) To investigate whether the management of voltages in the transmission network would be helped by placing voltage support obligations on some distributed energy resources.

(b) To investigate whether the management of voltages in the transmission network would be helped by managing reactive power flows between distribution networks and the transmission network.

(c) To investigate whether, with the expected uptake of inverter-based variable and intermittent generation over the coming years, the threshold for automatically excluding generating stations from the fault ride through asset owner performance obligations should be amended.

3.17. The high-level scopes of these system studies were developed, respectively, with assistance from a frequency sub-group and a voltage sub-group of the Common Quality Technical Group. The full Common Quality Technical Group then reviewed the final high-level scopes of the studies.

3.18. In undertaking the voltage-related studies, the system operator was aided by network information received from several distributors. This has helped improve the real-world relevance of the studies.

3.19. The reports for these studies have been published alongside the relevant options paper. The Common Quality Technical Group has considered and provided feedback on drafts of the study reports.

3.20. The Authority welcomes submitter feedback on the study reports.

It is too soon to consult on options to help manage harmonics

3.21. The Authority considers it is too soon to consult on a short list of options to be investigated further to help address the identified harmonics-related issue. We have reached this conclusion after discussion with the Common Quality Technical Group.

3.22. First, we want to consult with interested parties on our current thinking on the governance and management of harmonics. The management of harmonics receives relatively little attention in the Code and in other regulatory instruments. Fewer people in the electricity industry are familiar with harmonics compared to frequency and voltage.

3.23. We consider a better outcome will be achieved for consumers and industry participants if, as a first step, we describe what we see as the important elements of managing harmonics. Doing this will help facilitate having ‘everyone on the same page’ before we discuss more fully what options are likely to help address the identified issue.

We plan to consider some options not in the short list

3.24. The Authority is not discarding all options removed from the long list. We have decided to defer further consideration of several options for the time being and plan to return to these within the next 12–24 months.

4. The Authority is progressing some options sooner

4.1. The Authority has decided to progress some options sooner by going directly to proposed Code amendments. These options are to help address the final two identified key issues (6 and 7) with the common quality requirements in Part 8 of the Code:

(a) Network operators have insufficient information on assets wanting to connect, or which are connected, to the power system to provide for the planning and operation of the power system in a safe, reliable, and economically efficient manner.

(b) The Code is missing some terms that would help enable technologies, and contains some terms that appear to not be fit for the purpose of appropriately enabling technologies.

4.2. We consider preferred options to help address these issues are more readily identifiable than for the first five issues.

4.3. The Authority plans to consult with interested parties on proposed Code amendments to help address these issues in late 2024.

Main options under consideration to help address the information-related issue

4.4. At the time of writing, the Authority is considering four main options to include in a proposed Code amendment to help address the information-related issue. These options are:

(a) Require wind generation to undertake periodic testing and provide results to the system operator and as appropriate to distributors, so they can keep their power system models up to date.

(b) Lower the threshold for generating stations to provide real time operational data to the system operator and as appropriate to distributors.

(c) Require asset owners (grid-connected parties, grid owners, and embedded generators) to provide asset capability information that network operators and network owners require to meet their regulatory obligations.

This includes asset owners providing network operators with sufficiently detailed information to enable the network operator to assess equipment performance and to check compliance with relevant technical requirements on the asset owner set out in the Code (eg, the system operator checking compliance with technical requirements in Part 8 of the Code).

(d) Require asset owners (grid-connected parties, grid owners, and embedded generators) to support investigations into control interactions over the generating

life of generating assets they own and/or which are connected to their asset(s) (in the case of network owners).[16]

Options under consideration to help address the Code terminology-related issue

4.5. At the time of writing, the Authority is considering including several categories of options in a proposed Code amendment to help address the issue related to Code terminology.

4.6. These categories of options include:

(a) Removing some technology-specific references (eg, for some Code obligations replacing the reference to ‘speed governor’, a term relevant to machine-based synchronous generating units, with a reference to ‘frequency control system’, which is technology neutral).

(b) Making existing definitions fit for purpose and introducing new definitions (eg, ‘grid following inverter’, ‘grid forming inverter’, ‘asynchronous generation’, ‘virtual generation’, ‘virtual load’, ‘variable generation’).

4.7. The Authority notes we will be taking care to ensure options we propose to help address the Code terminology issue are neutral as to which technology (machine-based / inverter-based) and fuel type can provide the required service / output.

16 ‘Control interactions’ refer to situations where a generating unit is oscillating or interacting with another generating unit (or units), leading to undamped voltage, active and/or reactive power oscillations at the point of connection. Under this option, the asset owner (and possibly the inverter manufacturer) would have an obligation to support any investigation into the cause of these oscillations, to avoid the grid becoming more unstable as additional generating units come online. This support would be in the form of providing the asset owner's electro-magnetic transient model of the generating asset(s) to the person undertaking the investigation.