Enhancing hosting capability into Part 6 of the Code

Decisions paper

Decision

20 May 2019

Market Services

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1 Decision

1.1 The Electricity Authority (Authority) has decided to develop a Code amendment proposal to:

(a) change eligibility criteria for Part 1A of schedule 6.1 of the Code

(b) allow distributors to use a recognised method to determine hosting capacity on networks and specify a voltage threshold

(c) require distributed generators to comply with the distributors requirements for voltage thresholds.

2 Background

2.1 Part 6 of the Code regulates how distributed generation may connect to a local network. In December 2016, the Electricity Engineers' Association (EEA) proposed a Code amendment that would require additional criteria for applications to connect distributed generation using the process set out in Part 1A of schedule 6.1. The additional criteria relate to optional capabilities specified in technical standards that an inverter must possess to make it eligible for review using the Part 1A connection application process.

2.2 Before making a decision on the EEA's request, the Authority sought to elicit a wider range of views from interested parties on the implications of connecting more small-scale distributed generation (SSDG), storage batteries and electric vehicle in-home chargers to distributors' low voltage networks. Collectively, these technologies are referred to as distributed energy resources (DER).

2.3 The Authority was also cognisant of relevant parallel work streams being undertaken in the industry in the new technology space, including:

(a) the work of the Innovation and Participation Advisory Group (IPAG) about access to electricity networks

(b) development of a new technology pathway for distributors by the Electricity Networks' Association (ENA)

(c) information gathering by the Commerce Commission about emerging technologies.

2.4 The Authority developed an issues paper that:

(a) provided background about the regulations governing connection of distributed generation to distribution networks

(b) described three emerging problems that appear to have an adverse effect on reliable supply with increasing levels of SSDG:

(i) concentrations of rooftop solar PV generation may lead to sustained high voltages locally

(ii) concentrations of rooftop solar PV generation may lead to network congestion

(iii) incorrect inverter protection settings can affect the ability of SSDG installations to remain connected during network faults

(c) considered potential solutions to address these problems and proposed a preferred option

(d) sought feedback from interested parties on:

(i) the issues and options presented

(ii) two other related issues, one being a question of alignment of capacity classes between the Code and the AS/NZS 4777 suite of technical standards and the other related to the additional burden that an increasing level of installations of in-home electric vehicle chargers will have on low voltage networks.

2.5 An issues paper was released on 4 September 2018 as part of the omnibus consultation package, and submissions closed on 13 November 2018. The Authority received 19 submissions, from the parties listed in the table below. The submissions are available on the Authority's website and are consolidated in a table format in Appendix B.

Generator-retailers	Distributors	Other
Contact Energy Genesis Energy Trustpower Pioneer Energy	Aurora Energy MainPower Network Waitaki Northpower Orion Powerco Unison Networks Vector Wellington Electricity	A Miller Consulting Electricity Engineers' Association (EEA) Independent Electricity Generators Association Sustainable Electricity Association of New Zealand Transpower Wellington Electrical Design

2.6 The following sections describe the main themes arising from submissions, and summarise where there is a consensus of views. There were some dissenting views raised and these are noted in the submissions summary document.

2.7 Having considered all submission received, the Authority has concluded an amendment to Part 6 is required to address the issue.

3 There is general agreement that the issues paper correctly identified the anticipated network problems

3.1 Relative to many other rapidly decarbonising countries, New Zealand is at an early stage of consumer adoption of new network-connected technologies, particularly rooftop solar PV installations, some of which incorporate a storage battery, and in-home electric vehicle chargers (which, if fitted with 'vehicle-to-grid' capabilities, may become generators in the future). These technologies are collectively referred to as distributed energy resources (DER).

3.2 Drawing on international experience, New Zealand's electricity distributors anticipate future challenges with hosting DER on their low voltage networks, once adoption starts to evolve in clusters in advance of more widespread uptake. In this context, 'hosting' means to connect and operate new technologies on electricity networks, utilising the existing capacity in the network, and thereby enabling a range of new services. Hosting

benefits can include increased energy self-sufficiency, cost efficiency and the ability to participate in evolving electricity markets, such as the reserves market.

3.3 Orion agreed and commented

> *"Even when the total installed solar PV are small clustering is still possible causing localised issues (e.g. new subdivisions, high uptake in a particular street or area). This is most likely to affect our low voltage system.*
>
> *All solar PV in an area is likely to generate (or not) at the same time (e.g. when the sun's shining). In other words not much diversity. If most inverters react in the same way, then that's also against diversity. Both are not ideal. Batteries could either alleviate or reinforce this."*

3.4 The Authority agrees that there is likely to be little diversity within a low voltage network area, and this is what will cause localised congestion problems.

3.5 Unison also agreed, but also commented

> *"Unison supports this, provided consideration is given to the practical aspects of ensuring correct settings are activated, secured and maintained……"*

3.6 The Authority agrees that there will need to be requirements to ensure that correct settings are actually used, and are not amended or removed at a later date.

3.7 Vector commented

> *"Vector generally supports initiatives that promote the use of the latest technical standards, including standards for inverters for small-scale distributed generation (SSDG). In our view, the latest SSDG inverter standards should be adopted in a manner that would enable greater uptake of new technologies and mass participation in electricity markets, while maintaining network integrity and safety"*

3.8 The Authority agrees that adopting new technology must not compromise network integrity and safety.

3.9 Vector also commented

> *"Mandating or codifying (i.e. embedding into the Code) technical standards for new technologies imposes the following limits:*
>
> *a. Market competition is limited by locking out existing and potential market participants who are not currently using the required standards or who believe that better standards/ approaches are available, or could become available. This effectively becomes a barrier to market entry, stifling competition.*
>
> *b. Where barriers to entry are created, consumers will not benefit from lower cost service provision or the choice of better services that meet their specific needs……"*

3.10 The Authority notes that requiring specific inverter power quality modes is an eligibility criteria for access to the more streamlined Part 1A application process. If new technology becomes available based on different standards, the Part 1 application process provides a more generalised application process. This should ensure that barriers to entry are not created.

3.11 However, New Zealand's current rate of DER uptake should be put into context. As at the end of March 2019:

(a) the Authority's EMI data indicates that nationwide capacity of small-scale rooftop solar PV has reached 82 MW, or around 1% of total generation capacity, and is growing linearly at a rate of 1.4 MW per month

(b) settlement information from the reconciliation process indicates that the electricity injected into networks from distributed generation of less than 10 kW capacity is increasing steadily year by year. The cost of photovoltaic generation is decreasing and a point will be reached where growth will become exponential. The graph below indicates the total injection of small scale distributed generation (SSDG) into networks from 1 May 2008 (note that this injection figure does not represent total DER that is offsetting consumption, it is only what is left over from distributed generation after consumer self-consumption is removed), refer to the graph below

(c) Ministry of Transport vehicle fleet statistics indicate there are 9,850 'pure electric' vehicles registered in New Zealand, with recent growth running at 450 – 500 new registrations per month – this compares with around 26,600 petrol/diesel new and used light vehicle registrations per month.

3.12 Several other international markets have progressed at significantly faster adoption rates than New Zealand, which provides us with important learning opportunities.

3.13 Turning to the technical network issues discussed in the issues paper, comment from submitters supports the view that the low voltage network issues identified in paragraph 4.3(b) have yet to be encountered. Nevertheless, international experience shows that they are real issues that could materialise quite quickly, particularly if light electric vehicle uptake rates were to accelerate.

3.14 Submitters suggested a range of other problems related to the issues paper main topic, including:

(a) the potential for power quality issues to emerge related to power system voltage and current harmonics – inverters can generate high levels of harmonics (ie fundamental frequency multiples such as the 150 Hz '3rd harmonic', etc) that can cause power quality issues and are not adequately addressed in code of practice NZECP 36:1993. Staff have referred this issue to MBIE for comment who have indicated that this is currently not an active issue.

(b) that issues may not be limited solely to low voltage networks but may be reflected 'upstream' into higher voltage distribution networks

(c) that low voltage networks hosting growing concentrations of DER will, over time:

(i) become increasingly difficult to manage in real time, because voltage and power flow on low voltage networks are not monitored by the types of system control and data acquisition (SCADA) systems distributors have traditionally deployed

(ii) bring forward consideration of the need for a distribution system operator (DSO) role for distributors, that actively monitors and operates distribution networks as a platform for a range of DER-enabled hosting services

(iii) expose a critical information gap about local DER uptake, because consumers that own electric vehicles are not obliged to notify the local distributor if they install an in-home electric vehicle charging appliance, in particular a high-capacity 7 kW unit (or higher). A 7 kW charger is very large relative to the demand of other household appliances and clusters of new

chargers would likely create network capacity and power quality concerns for distributors if they charge at the time of the winter evening peak household heating and cooking loads.

(d) that New Zealand adopted revised inverter standards (AS/NZS 4777.2:2015) 4 years ago. While the Code has been updated to refer to the revised standard, the Electricity (Safety) Regulations 2010 have not. This is causing significant issues in the certification of installations containing inverters. The Authority referred this issue to MBIE for comment.

3.15 Submissions are broadly consistent with recent Innovation and Participation Advisory Group (IPAG) advice to the Authority, summarised in the IPAG report *Advice on creating equal access to electricity networks, April 2019*.[1] Specifically, the following selected points from the summary on page 3 of that report are relevant:

(a) *Distributed Energy Resources (DER – ie, solar, battery storage and automated demand response) investment is happening in NZ, albeit at a slower pace than other countries. The lesson is the DER market has to be allowed to develop.*

(b) *The rise of DER can cause technical problems for networks, and this is already occurring.*

(c) *To accommodate the impact of DER and its potential use in network management, industry participants − in particular distributors − and regulators will need to respond with a sense of urgency, starting in 2019.*

3.16 Nevertheless, consistent with IPAG advice, submissions on the issues paper support the Authority moving now to develop 'no-regrets' initiatives, in particular initiatives that would enhance standardisation of network technical standards, while relevant markets in DER are allowed to form over a longer timeframe.

4 Submissions expressed general support for mandatory adoption of advanced power quality modes in inverters

4.1 The issues paper suggested there are three main options the Authority could consider, which in summarised form are:

(a) Option A: watch and wait – there is no urgency at this stage

(b) Option B: enhance the effectiveness of inverter technical standards by mandating adoption of specific advanced power quality modes referenced in Part 6 of the Code

(c) Option C: consider a more comprehensive amendment to Part 6 – the paper requested submitters that support this option to outline their proposal.

4.2 Advanced power quality modes refer to inverter capabilities that change the inverter's electrical output in response to the electrical conditions measured at the inverter's terminals. These modes are designed to support local power quality and may be enabled or disabled. They include the following modes:

(a) volt response modes

[1] https://www.ea.govt.nz/dmsdocument/25026-ipag-final-advice-on-equal-access

(b) fixed power factor or reactive power mode

(c) power response mode

(d) power rate limit.

4.3 Option B proposed the use of the volt response modes.

4.4 Submitters broadly agree that the issues paper presented an appropriate range of options. No submissions supported option C. This provides some confidence in the overall effectiveness of Part 6 as a starting point for considering possible enhancements.

4.5 While a small number of submitters expressed support for the 'watch and wait' option A, there was more general support for option B. In particular, in support of an option B variant:

(a) submitters expressed a range of views about inverter capabilities available now in the market, specifically that inverters available for purchase by solar PV system installers already possess the advanced power quality modes sought

(b) those submitters that expressed a view considered there would be little or no incremental cost for requiring the advanced power quality modes

(c) submitters expressed a range of views about unintended consequences if optional power quality modes were made mandatory but raised no major concerns.

4.6 Contact Energy preferred to wait until an issue eventuates, and also review lessons from overseas

> *"As the EA mentions, solar PV is at a low level in New Zealand, and without policies to incentivise investment, deployment has been fairly consistent for the last few years. Therefore, given there is no pressing need to do anything now, our view is to wait and review lessons from international distributors taking a market-based approach to solving these potential issues."*

4.7 The Authority notes that these lessons are already apparent in low voltage networks in Australia. While the current installation rate is slow, a reduction in the cost of panels or electricity could cause rapid exponential growth.

4.8 The EEA supported Option B and commented

> *"EEA supports the EA looking at option B. Although current SSGD levels are low, option B appears to be a reasonable 'least regrets' approach. Ideally Volt-VAr and Volt-Watt capability should be enabled before we see an accelerated uptake of SSDG to enable better outcomes and future proof the system."*

4.9 Unison commented similar to the EEA

> *Unison supports Option B. However, we would ask that the Authority consider extending the use of advanced volt-watt and volt-var modes on all SSDG installations, regardless of whether there has or will foreseeably have, limited hosting capacity.*

4.10 The Authority notes the support for a "no regrets" approach.

4.11 Overall, submissions support adoption of option B as a 'no regrets' option. We note the following key points in support of this option:

(a) inverters supplied into New Zealand are sourced from a global market in which enhanced inverter capabilities are driven by the requirements of the more rapidly de-carbonising, technically-advanced countries – of most relevance, Australia

(b) therefore, the advanced inverter power quality modes that would provide low voltage networks with a material degree of power quality self-management, are already available

(c) further, that these modes are available at zero or very low incremental cost – as compared with 'old standard' inverter models that do not possess the advanced modes.

4.12 Of note is that adopting option B is consistent with the technical standards development pathway emerging in countries that are well ahead of New Zealand in terms of experiencing real network problems from high DER penetration levels. The international trend is towards mandatory adoption of advanced power quality modes in inverter technical standards.

4.13 Moving ahead with option B now would see Part 6 anticipating the next move in which the local AS/NZS 4777 standards suite eventually mirrors the international standards the suite is based on. Confirming requirements for the advanced power quality modes now would enhance regulatory certainty for solar PV installers.

4.14 Another suggestion made by some was that there is no need to reject 'old standard, less capable' inverters out of hand. Applications made under Part 6 to connect such inverters could still be processed through the Part 1 process, which provides for a more in-depth review of a connection application.

4.15 In contrast, the Part 1A process was designed to streamline distributor reviews of connection applications that incorporate a standards-compliant inverter. Implementing this suggestion would involve simply amending the criteria for access to the Part 1A application and approval process. This appears to form the basis of a strong option that would sidestep issues associated with stranding remaining 'old standard' inverters.

5 Submitters consider the EEA's hosting capacity assessment methodology is a useful guide

5.1 Section 5 of the issues paper outlined an EEA-coordinated initiative that produced a draft guide for the connection of small-scale inverter-based distributed generation and a methodology for assessing the hosting capacity of existing low voltage networks.

5.2 The draft EEA guide represents a significant industry-led initiative. At the current time, it remains in draft form as it is based on the latest AS/NZS 4777 inverter standards suite and, to be fully effective, requires adoption of specific inverter modes that are included in the standard as optional modes only. EEA has no authority to require adoption of the optional advanced power quality modes. Option B would remedy this shortcoming in the draft guide.

5.3 Submitters expressed support for the objectives of the EEA draft guide and also broadly supported the EEA's Code amendment request that would give full effect to the guide.

6 Other related topics discussed in the issues paper prompted a range of views

6.1 The issues paper requested submissions about two other matters related to DER connected to low voltage networks:

(a) capacity threshold alignment between Part 6 and the AS/NZS 4777 standard suite

(b) matters related to in-home charging of electric vehicles.

6.2 On the question of capacity threshold alignment, submissions were divided as to whether there was a problem. Nevertheless, some suggested that alignment had merit and should be further considered as providing a further improvement to Part 6, albeit a relatively minor one.

6.3 Another issues paper question asked whether submitters considered that in-home electric vehicle chargers may cause low voltage network capacity or power quality problems. Submitters notably provided a wide range of detailed views, indicating a significant depth of interest in this aspect of DER deployment.

6.4 The relative uptake rates of light electric vehicles and rooftop solar PV, enumerated in paragraph 3.14(c) above, support a view that network issues arising from electric vehicle uptake may eventuate more rapidly than those caused by emerging clusters of residential solar PV.

6.5 While responses broadly supported this view, submissions noted that questions remain over the speed of deployment and whether adoption of the relatively expensive 7 kW in-home chargers becomes widespread. These variables relate to the additional after diversity maximum demand (ADMD) that electric vehicle charging may ultimately impose on low voltage networks – and, hence, to the scale and pace of the potential problem.

6.6 Northpower commented that there is insufficient known at this time on charging patterns to reach a decision

> *"There are diverging opinions. New EVs have higher capacity batteries and more powerful chargers; however that doesn't mean they will necessarily travel further per day and consume more energy. EVs with higher capacity batteries will not need to charge as often. There needs to be consideration of diversity instead of assuming all EVs will be charged at home daily and at the same time….."*

6.7 The Authority notes that there are differing opinions and charging patterns of New Zealand consumers is not known at this time.

6.8 A number of distributors supported carrying out further investigation. For instance, Orion NZ commented

> *As the uptake of electric vehicles increases it is realistic to assume that capacity and power quality issues will emerge. Initially this will be at local level (clustering) before becoming more widespread across a network….*
>
> *Therefore we consider it pre-emptive and prudent to bring in the requirement for a process for connection of electric vehicle chargers under Part 6. Taking this no regrets approach may potentially work alongside monitoring efforts to head-off any connection technical issues, but it may also help facilitate competitive retail offerings to customers in the future.*

6.9 Powerco commented

Yes. Not only standard voltage and current ratings, but also harmonics and high frequency noise. We have seen an article from a metering equipment supplier describing 8kHz noise from an EV charger.

6.10 Unison Networks considered that the future challenge will be more with fast chargers, and commented

"Unison is already considering the effects that electric vehicle chargers may have on the network, in particular the 'clustering' effect in certain areas. However, we see the impact will be greater with fast chargers,….."

6.11 Network Waitaki noted that issues were yet to be experienced, but also added that visibility of EV charger locations was essential suggesting an application process similar to that used for distributed generation

"We have not yet experienced issues from in-home EV chargers. As EV penetration increases so too will the effects on LV networks. Issues may first appear in clusters around more affluent neighbourhoods.

We believe the most prudent way to manage the effects of EV chargers, and to schedule investment to augment our LV networks, is to:

a) know where all EV chargers are located.

b) be able to measure, in real time, voltage and current at our consumer premises or Point of Supply.

c) Have the ability to time-shift, or as a last resort throttle charge rates of individual EVs to ensure that our LV voltages remain within regulated levels.

We believe that a) is essential and could be achieved with a connection process similar to SSDG Part 1a."

6.12 The Authority has noted these issues and will investigate these further.

6.13 Other views held that electric vehicle charging is just another consumer load, albeit a relatively large one that could, suitably configured with a communications link, provide a demand response resource. In a similar way to residential water heating loads, the opportunity exists for a market in demand response. The two technologies are similar in that both:

(a) can impose relatively high demands on the local network – electric vehicle charging requires 2.3 – 7 kW versus storage water heating at typically 3 kW

(b) require 'topping up' (charging) an energy store that is consumed later – electric vehicle battery versus hot water storage cylinder

(c) have flexibility about when charging/heating needs to occur without imposing a loss of amenity to the driver/energy consumer.

6.14 A further theme emerging from submissions is the view that distributors will need to better monitor voltage and power flow on their low voltage networks, ideally in real time. The strong consensus that power flows across low voltage networks will become increasingly dynamic as DER proliferates in increasingly dense concentrations, supports this view.

6.15 The recent IPAG report referred to in section 3 provides significantly more detail and advice about the specific problems that increasing DER might pose and the

opportunities for markets to develop in relevant services. The takeaway in respect of the Part 6 amendment being considered in this paper is that pursuing option B now would:

(a) provide greater standardisation of technical standards affecting consumer DER installations that are connecting to low voltage network at a steady rate

(b) lay the technical groundwork for markets to develop in hosting services

(c) provide regulatory certainty regarding technical standards that align with international standards development pathways.

7 Amending part 6 would be likely to resolve the issue

7.1 While submissions on the issues paper have discussed a wide range of DER-related issues, feedback related to the central topic within the issues paper indicates there is general support for a move now to amend Part 6 of the Code, to require specific advanced power quality modes of operation in inverters.

7.2 Specifically, option B appears to provide long-term benefits to consumers, including the increasing numbers of consumers considering DER investments, by promoting:

(a) supply reliability, particularly on low voltage networks but, in general, across all levels of the interconnected network

(b) the basis for enhanced competition in emerging markets in DER hosting services

(c) efficient operation of the electricity industry by enhancing regulatory certainty about the technical standards required to extend the hosting capacity of existing low voltage networks, deferring the need for distributors to incur significant new capital expenditures.

8 Submitter views support further investigation of in-home electric vehicle charging

8.1 The discussion paper prompted significant interest in the topic of in-home electric vehicle charging. The key submission points are summarised above, starting at paragraph 6.3. The feedback supports more comprehensive investigations of the impacts of widespread in-home electric vehicle charging.

8.2 The Authority notes that the development path of in-home electric vehicle charging depends on a number of external factors, including the development of hydrogen as a fuel source, larger capacity vehicle batteries and rapid chargers. While it is still early days, transformation scenarios in which electrification of the vehicle fleet passes a tipping point may require significant asset investment and operational challenges for distributors.

8.3 The problems include:

(a) Dramatically increasing electricity generation necessary to ‘fuel’ the expanding electric vehicle fleet. Currently, New Zealand generation provides around 43 TWh of electricity annually. Transpower’s Te Mauri Hiko – Energy Futures (2018) white paper estimates the additional electricity required to power 85% of light transport by 2050 is 13 TWh (equivalent to the combined annual production of Manapouri and the Waitaki River chain of stations). This represents an increase in consumption and distribution of approximately 31%.

(b) Providing capacity within the national grid and distribution networks to transmit grid and distribution network-connected generation to a vastly increased network of electric vehicle charging points, at times that could coincide with existing winter evening peak demands. This will provide challenges throughout distribution networks, particularly affecting the low voltage networks that supply in-home electric vehicle chargers.

(c) Operating grid and distribution networks in an environment of significantly changed generation and demand patterns, while maintaining service security, reliability and power quality. In the past, distributors have not needed to monitor the voltage, power flow, phase balance or harmonic content in their low voltage networks on a routine basis. More dynamic local power demands will increasingly expose this shortcoming.

8.4 At this time, significant uncertainty exists about how potential issues may play out. This point also came through strongly in a recent Authority survey of distributor and stakeholder views about the impacts of emerging technologies.

8.5 The Authority agrees that rapid change may lead to challenges but expects distributors to take the lead in monitoring the situation, framing the issues and proposing and socialising strategies and solutions. Along with Transpower's grid-level perspective, distributors are best placed to develop strategies that seek to anticipate and mitigate evolving business risks.