Meeting Date: 27 May 2021

FIT-FOR-PURPOSE REVIEW: REGULATION AND MONITORING - CONSUMER PREMISES EQUIPMENT

SECURITY AND RELIABILITY COUNCIL

This paper is part of a series that investigates the extent to which current regulation is fit-for-purpose in terms of current and near-term circumstances. This paper addresses risks specific to consumer premises equipment.

Note: This paper has been prepared for the purpose of prompting SRC discussion about risk management within the industry. Content should not be interpreted as representing the views or policy of the Electricity Authority.

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1 Fit-for-purpose review of consumer premises equipment risks

1.1.1 The Security and Reliability Council's (SRC) functions under the Electricity Industry Act 2010 include providing advice to the Electricity Authority (Authority) on:

a) the performance of the electricity system and the system operator; and

b) reliability of supply issues.

1.1.2 In pursuit of its purpose, the SRC developed a risk management framework to identify key arrangements for managing risks to reliability of supply. The framework identified the regulatory arrangements for assessing and managing consumer premises equipment as warranting periodic SRC attention.

1.1.3 The purpose of this paper is to enable the SRC to formulate advice to the Authority on whether regulatory arrangements relating to consumer premises equipment are effective in managing the risk of widespread reliability events. This includes whether regulation and compliance monitoring of consumer premises equipment is adequate, is keeping up with technology changes and is fit-for-purpose.

1.1.4 To inform that advice, the paper:

a) describes the current regulatory arrangements relating to consumer premises equipment; and

b) assesses whether current regulatory arrangements are effective in managing potential widespread reliability events.

2 Regulatory arrangements for consumer premises equipment

2.1.1 This section describes the current arrangements for consumer premises equipment relevant to the reliable supply of electricity to consumers.

2.1.2 While the *electrical safety* of consumer premises equipment is comprehensively regulated, there is no specific regulation related to the *functionality or performance* of consumer premises equipment in circumstances where such equipment could have adverse effects on an electricity network or the grid. This section will explain this in more detail.

2.2 What is consumer premises equipment?

2.2.1 At a high level, consumer premises equipment is electrical equipment (smart appliances, distributed generation and energy storage systems located within a consumer's premises and electrically connected on the premises side of the electricity meter.

2.2.2 In more detail, section 2 of the Electricity Act 1992 includes somewhat convoluted definitions relevant to identifying the boundaries between 'works', 'electrical installation' and 'electrical appliances'. In simple terms, the boundary between *works* and an *electrical installation* is at a *point of supply*, where:

a) *works* refers to the electrical supply equipment in the local distribution network that together acts to supply electricity to, or receive electricity from, the consumer premises (e.g. lines, cables, transformers, substations etc);

b) *electrical installation* refers to the electrical supply equipment within the premises (e.g. switchboards, cables, fittings) that conveys electricity:

i. to an electrical appliance; or

ii. from an in-premises generator (e.g. a rooftop solar PV installation) or an electrical storage device (i.e. battery energy storage systems (BESS));

c) *point of supply* is the boundary between works (i.e. the local distribution network) and an electrical installation (the consumer premises); and

d) an *electrical appliance* is a device that consumes electricity by transforming it to another form of energy (e.g. light bulb (light, heat), water or space heater (heat)).

2.2.3 For the purposes of this paper, while not strictly accurate, we will treat the point of supply as being equivalent to the metering installation (including an Advanced Metering Infrastructure (AMI) metering installation) provided at the Installation Control Point (ICP) in accordance with Part 10 of the Electricity Industry Participation Code 2010 (the Code).

2.2.4 So, finally, consumer premises equipment includes:

a) *electrical installations*, which convey electricity within premises;

b) *electrical appliances*, which consume electricity by transforming it to another form of energy;

c) *distributed generation*, which generates electricity by transforming another form of energy into electricity; and

d) *BESS*, which store electricity as chemical energy and transform it back to electricity at a later time.

2.2.5 In-premises distributed generation and BESS use direct current (DC) electricity internally and electrically connect to the electrical installation, which uses alternating current (AC) electricity, through an inverter.[1]

2.3 WorkSafe regulates electrical safety

2.3.1 While WorkSafe New Zealand (WorkSafe) is New Zealand's primary workplace health and safety regulator, it has other responsibilities not directly related to the workplace, including administering other safety-related regulations.

2.3.2 The area relevant to the safety of consumer premises equipment is the regulations under the Electrical (Safety) Regulations 2010 (the ESRs). This includes the Electrical Code of Practice on harmonic levels which applies at electrical installation level through distributor's connection standards.

2.3.3 However, WorkSafe does not have the power to regulate aspects of appliance standards relating to the appliance's functions, modes and non-safety-related

[1] The inverter standard AS/NZS 4777.2:2020 defines 'inverter' as a device that uses semiconductor devices to transfer power between a DC source or load and an AC source or load. Inverters are therefore bidirectional power converters.

performance. An inverter is an appliance with particular relevance when connecting new electrical technologies to an electrical installation, such as solar PV systems and BESS.

2.3.4 The way an inverter performs its functions, for example through the operation of the electrical protection functions and advanced power quality modes, can have a material impact on external networks including the national grid. This is especially the case when smaller-scale DER systems are installed in very large numbers, with individual system capacities aggregating to many MW.

2.3.5 An inverter can provide active control of its input or output ways that affect local voltage and national grid system frequency. Coordinated settings of directly or indirectly network-connected inverters is very important.

2.4 The Authority regulates the connection of distributed generation under Part 6 of the Code

2.4.1 Distributed generation is generation connected directly or indirectly to a distributor's local network. Distributed generation that is consumer premises equipment connects indirectly to a local network through the consumer premises. Distributed generation can incorporate a BESS.

2.4.2 Small-scale distributed generation has capacities up to 10 kilowatts (kW). These small-scale systems typically provide DER for businesses, homes or farms. Larger distributed generation schemes, usually directly connected to a local network, may have capacities up to several tens of megawatts (MW).

2.4.3 Increasingly frequently, as technology costs steadily decrease, small-scale distributed generation system designs include BESS and a smart controller to obtain optimal system performance (given BESS charging and discharging is an entirely controlled function).

2.4.4 Regulations relevant to connection of distributed generation were introduced in the Electricity Governance (Connection of Distributed Generation) Regulations 2007 (the DG Regulations). The purpose of those now-revoked regulations was to enable connection of distributed generation where connection is consistent with connection and operation standards.

2.4.5 The DG Regulations provided a consistent process for submitting and assessing an application to connect. They included default regulated terms of connection, a dispute resolution process and pricing principles. The DG Regulations provided separate processes for:

a) Small-scale distributed generation, i.e. for systems of 10 kW capacity or less

b) distributed generation systems with a capacity more than 10 kW.

2.4.6 In 2010, the DG Regulations were brought into the inaugural Code as Part 6 and have been subsequently reviewed and amended at various times. The most recent review of Part 6 is currently subject to consultation and a decision by the Authority to amend Part 6 (or not).

2.5 Distributors must publish connection and operation standards

2.5.1 Distributors use connection standards to manage safety, performance, and reliability issues on their network. This includes limits on reactive power and harmonics. In addition, clause 6.3(2)(b) of the Code requires that distributors publish *connection and operation standards* relevant to distributed generation.

2.5.2 Connection and operation standards relate to directly or indirectly (i.e. via an electrical installation) connecting distributed generation to a distribution network, <u>and the operation of the distribution network</u>, including requirements relating to the planning, design, construction, testing, inspection, and operation of distributed generation that is, or is proposed to be, connected.

2.5.3 Connection and operation standards must:

a) be set out in written policies and standards of the distributor;

b) be made publicly available;

c) reflect, or be consistent with, reasonable and prudent operating practice;

d) include the distributor's:

   i. congestion management policy, as referred to in clause;

   ii. emergency response policies; and

   iii. safety standards.

2.5.4 Connection and operation standards are therefore subject to individual distributor policies and preferences, yet must reflect or be consistent with reasonable and prudent operating practice.

2.5.5 In setting policies and their connection and operation standards, we understand that most distributors broadly follow a national good practice guide developed by the Electricity Engineers' Association (EEA).

2.5.6 The primary standard that comprehensively covers the inverters sold in New Zealand is AS/NZS 4777.2:2020. The 2020 update of this standard replaced earlier versions published in 2015 and 2005. Of note is that the ESRs have not been updated to reference the latest versions of the AS/NZS 4777 standards suite. The SRC recently gave advice to the Authority to have WorkSafe prioritise updating of the outdated AS 4777:2005 standards suite.

3 Are regulatory arrangements for consumer premises equipment effective in managing the risk of widespread reliability events?

3.1 Overview

3.1.1 This section:

a) identifies risks that could result in widespread reliability events

b) assesses whether current regulatory arrangements for consumer premises equipment are effective in managing these risks.

3.1.2 The consumer premises equipment with the largest adverse consequence if maliciously controlled by a cyber-attacker is electricity metering. Most domestic metering can be remotely disconnected and reconnected, though there is scant regulation of its cyber-performance.

3.1.3 Commonly encountered consumer premises equipment (e.g. toasters, lights) are most unlikely to cause widespread reliability issues. The consumer premises equipment with the greatest future potential to cause or contribute to supply reliability issues for other network users is:

a) DER, particularly those devices with sufficient capacity to inject energy into the network, such as distributed generation and BESS; and

b) remotely controllable or programmable loads, such as those suitable for demand management. Examples include EV chargers, heat pumps, refrigeration, commercial HVAC.

3.1.4 The current regulatory arrangements for consumer premises equipment may not be fit-for-purpose in the future, with materially increased penetrations of DER within consumer premises equipment.

3.1.5 Given the expected changes to the New Zealand electricity industry over the coming decade and more, it would appear prudent to reassess these arrangements in 2–3 years' time.

Table 1: The Authority's initial evaluation of whether regulatory arrangements for consumer premises equipment are effective in managing the risk of major supply reliability events

#	Risk area	Risk to supply reliability	Initial evaluation: Impact threshold met?	Initial evaluation: Likelihood	Initial evaluation: Effectiveness of current arrangements
1	Under-frequency events impacting the entire grid are exacerbated by substandard or incorrectly set inverters at consumer premises	Solar PV and BESS indirectly connected to distribution networks through DC/AC power inverters may not 'ride through' (i.e. remain connected and operating) a major generation failure, thereby exacerbating grid-wide under-frequency events, and potentially triggering automatic under-frequency load shedding (AUFLS). Note: this is similar to an equivalent risk discussed in the transmission paper; in this case, the inverter is consumer premises equipment.	**Impact threshold met** An AUFLS event caused by inverters within DER not riding through major generation failures would have a material adverse impact on reliability and cause significant economic loss.	**Low likelihood of risk becoming an issue in the short term** The likelihood of this risk becoming an issue in the short term is low. This is due to the relatively small number, and low aggregate capacity, of inverters within DER relative to the capacity of the whole power system, and the rate at which specialist installers can install these smaller capacity systems. However, international experience is that the risk likelihood can increase quite quickly to material levels. DER system costs are decreasing rapidly, which will accelerate the number, and aggregate capacity, of installed inverters. Solar PV/BESS business models that reduce or eliminate the up-front installation costs, instead offering energy services through rented	**Effectiveness of regulatory arrangements needs to be improved** The system operator has recognised this identified risk and has undertaken relevant investigative work. In cooperation with the system operator, the Authority is scoping a work programme to review the performance aspects of the inverter standards for distributed generation. At the transmission level, the Authority is well underway with a review of Parts 8 and 13 of the Code that has as its objective the enablement of grid-scale (battery) energy storage systems (BESS) to provide instantaneous reserve. WorkSafe regulates electrical safety but that does not cover inverter performance as it impacts networks. The ESRs cite a very out of date

#	Risk area	Risk to supply reliability	Initial evaluation: Impact threshold met?	Initial evaluation: Likelihood	Initial evaluation: Effectiveness of current arrangements
				assets, may further reduce barriers to consumers considering DER. Legislation that cross-subsidises DER can lead to rapid uptake.	standard (AS 4777.1:2005) in respect of electrical equipment safety and this is a known issue.
2	LV and distribution network under and over-voltage events exacerbated by substandard or incorrectly set inverters at consumer premises	Solar PV and BESS indirectly connected to distribution networks through DC/AC power inverters may exacerbate local network over-voltage conditions, potentially triggering inverter shutdown or local high voltages adversely impacting the power quality received by network neighbours.	**Impact threshold met** Supply extreme over-voltages will damage appliances in local electrical installations would have a material adverse impact on reliability and cause significant economic loss.	**Low likelihood of risk becoming an issue in the short term** The likelihood of this risk becoming an issue in the short term is low. This is due to the relatively small number, and aggregate capacity, of inverters within DER, and the rate at which specialists can install these smaller capacity systems. However, international experience is that the risk likelihood can increase quite quickly to material levels. DER system costs are decreasing rapidly, which will accelerate the number, and aggregate capacity, of installed inverters. Solar/BESS business models that reduce or eliminate the up-front installation costs, instead offering energy	**Effectiveness of regulatory arrangements needs to be improved** The system operator has recognised this identified risk and has undertaken relevant investigative work. In cooperation with the system operator, the Authority is scoping a work programme to review the performance aspects of the inverter standards for distributed generation. At the transmission level, the Authority is well underway with a review of Parts 8 and 13 of the Code that has as its objective the enablement of grid-scale (battery) energy storage systems (BESS) to provide instantaneous reserves.

#	Risk area	Risk to supply reliability	Initial evaluation: Impact threshold met?	Initial evaluation: Likelihood	Initial evaluation: Effectiveness of current arrangements
				services through rented assets, may further reduce barriers to consumers considering such technologies. Legislation that cross-subsidises DER can lead to rapid uptake.	
3	Large capacity appliance consumption at times of peak network usage	Charging EVs coincident with a winter evening peak leads to severe network overloading and voltage collapse	**Impact threshold met** A 7 kW EV charger can double a residential premises peak demand. Without mitigations, LV networks in particular will struggle to maintain voltage within statutory limits and suffer severe power overloads. If this develops to become widespread throughout a network area, higher voltage distribution and sub-transmission facilities will also become increasingly likely to experience reliability issues through voltage collapse and outages.	**Low likelihood of risk becoming an issue in the short term** The likelihood of this risk becoming an issue in the short term is low, or at most experienced in very localised pockets. This is due to the relatively small number, and low aggregate capacity, of EV chargers relative to the capacity of the local network, and the rate at which consumers adopt EV vehicles.	**Effectiveness of regulatory arrangements needs to be improved** EV charging (like all domestic power use) is currently unregulated. It is left to distributors to monitor uptake and load profiles and inform consumers about potential issues. Some distributors have introduced time of use network pricing, including through tailored EV tariffs. Nationally consistent approaches including standardisation through regulatory arrangements should be considered. See also section 4.3 below.

#	Risk area	Risk to supply reliability	Initial evaluation: Impact threshold met?	Initial evaluation: Likelihood	Initial evaluation: Effectiveness of current arrangements
4	Inverters do not comply with standards or are set incorrectly	Inverters that do not conform with the appropriate standard or have settings tampered with may perform poorly in terms of frequency, voltage, protection, harmonic distortion and system event 'ride through', leading to local voltage outside statutory limits and/or exacerbating grid-wide under-frequency events, and potentially triggering automatic under-frequency load shedding (AUFLS).	**Impact threshold met** An AUFLS event caused by inverters within DER not riding through major generation failures would have a material adverse impact on reliability and cause significant economic loss. A grid level event in Australia in showed that with high levels of inverter-connected solar PV that conformed only with the old 2005 standard did not ride through the event and exacerbated the frequency disturbance.	**Low likelihood of risk becoming an issue in the short term** The likelihood of this risk becoming an issue in the short term is low. This is due to the relatively small number, and aggregate capacity, of inverters within DER, and the rate at which specialists can install these smaller capacity systems.	**Effectiveness of regulatory arrangements needs to be improved** The inverter standard AS/NZS 4777.2 is not currently regulated but is included in good industry guide developed by the EEA, including with appropriate settings for the advanced power quality modes provided by modern inverters. Through their connection and operation standards, distributors have the ability to require compliance with AS/NZS 4777.2. The standard is cited in Part 6 of the Code but its function in that part of the Code is as an eligibility criterion governing access to a faster track DER connection approvals process. See also section 4.3 below.
5	Cyber risk	Inadequate cyber security of consumer premises equipment leads to material	**Impact threshold met** Most DER that includes BESS provide network connectivity	**A reasonably likely possibility of a risk**	**Regulatory arrangements may not be effective**

#	Risk area	Risk to supply reliability	Initial evaluation: Impact threshold met?	Initial evaluation: Likelihood	Initial evaluation: Effectiveness of current arrangements
		harm to those systems, impacting supply reliability. A bad actor gains access to and control of critical IP-addressable network-connected consumer premises equipment, such as smart control systems and uses this access to disrupt consumer premises equipment. AMI is subject to cyber risk because it is networked.	between cloud-based monitoring and control apps. A full-scale cyber attack on an inadequately protected single system (as in from a single vendor) could give rise to widespread disruption. DER aggregation platforms are being implemented internationally and locally. These have the potential to aggregate many thousands of small-scale installations. There are around 1.8 million AMI installations, most of which can be remotely disconnected and reconnected by the provider.	**becoming an issue in the short term** For example, a 2018 Deloitte report[2] stated: *"The threat is now becoming even more insidious, with reports of hackers tied to nation-states and organized crime trying to burrow their way into utility ICS [Industrial Control Systems], seeking to learn how systems operate, and positioning themselves to control critical system assets, such as power plants, substations, transmission, and distribution networks, and to potentially disrupt or destroy them."*	Information disclosure requires publication of asset management plans. However, making mitigation strategies and defensive measures public would be counter-productive if it provides information that bad actors may use against the distributor. *Confidential presentations and surveys related to this risk have been commissioned and given to the SRC.* *Needs further assessment by specialists.*
6	Inadequate market arrangements for participation of new technology consumer	Aggregations of small scale DER is enabled in energy and ancillary services markets by Code amendments and changes to MOSP service terms. However, if dispatched resources fail to perform this	**Impact threshold met** A failure of instantaneous reserve to activate at the appropriate level of under-frequency would lead to an AUFLS activation, which would have a material adverse impact on reliability	**Low likelihood of risk becoming an issue in the short term** Market development initiatives are currently in progress, starting with grid-scale BESS participating in energy and ancillary markets. DER that is	**Regulatory arrangements appear effective** The Authority regulates the electricity market via the Code. Numerous complex improvements have been developed over many years and are fully operational.

2 https://www2.deloitte.com/content/dam/insights/us/articles/4921_Managing-cyber-risk-Electric-energy/DI_Managing-cyber-risk.pdf , page 4.

#	Risk area	Risk to supply reliability	Initial evaluation: Impact threshold met?	Initial evaluation: Likelihood	Initial evaluation: Effectiveness of current arrangements
	premises equipment.	could lead to AUFLS activation during an under-frequency event.	and cause significant economic loss.	consumer premises equipment is a near future initiative as realistic DER aggregation capabilities are coming to fruition.	Performance is monitored over time and major system events are monitored and, in some cases, subject to further investigation.

4 Conclusions for supply reliability risks related to electricity consumer premises equipment

4.1 Recapping what we have done

4.1.1 For each identified risk area in Table 2 above we stepped through:

a) a description of the risk as relevant to supply reliability;

b) an initial assessment of the identified risk in terms of:

   i. an event reaching the impact threshold; and

   ii. the likelihood of the risk occurring; and

c) an initial assessment of whether current regulatory arrangements appear to be adequate.

4.1.2 Of note is that the purpose of the risk identification and assessments presented in this paper is to prompt and assist informed discussion by the SRC of the risk areas that might fall within the SRC's attention criteria.

4.1.3 In several areas, the level of research and analysis required to provide more definitive advice is beyond the scope of the paper. In these cases, further development of the fit-for-purpose assessments will significantly benefit from input and feedback from the relevant regulators, in particular the Commerce Commission in respect of its role as the economic regulator of distribution businesses.

4.2 New consumer technology is driving multi-year generational change

4.2.1 It is well established that we live in times of very rapid change in many sectors of the economy. In electricity distribution in particular, long established assumptions about the network's roles are in the process of being completely turned around, albeit at an early stage. The direction of power flow on radial LV and distribution level circuits was not designed in when these networks were engineered. Without mitigations, power quality issues will rapidly become newsworthy events.

4.2.2 While we are fortunate in having access to lessons learned by our near neighbours, it is critical to regularly review the fitness for purpose of industry regulation that was largely developed under longstanding assumptions.

4.3 A Sapere Research review identified gaps and weaknesses in the governance of DER technical standards

4.3.1 Australia's Energy Security Board commissioned a review by Sapere Research Group on the governance of Australia's DER technical standards. Given the concerns raised at the 13 March 2020 SRC meeting about standards arrangements in New Zealand, this review is relevant. Sapere summarised their findings as follows:

"The Review highlights that to date the governance of DER technical standards has been fragmented, lacking clarity of roles and coordination. In addition, resourcing is inadequate and the pace of change is slower than needed given the rapid deployment of DER in the NEM. The result is that DER systems deployed today are not necessarily able to deliver the performance levels and services required to support system security, efficient and effective distribution network management and the optimisation of DER benefits for all electricity system users.

The Review identified critical gaps and weaknesses in the current governance system, including:

d) an overall lack of leadership and coordination and clear objective as to how DER technical standards should be governed.

e) weaknesses in the Standards Australia technical standards process in terms of speed, transparency, participation and decision making not being explicitly aligned with National Electricity Objective.

f) lack of harmonisation in network connection standards across Distribution Network Service Providers (DNSPs).

g) under-resourcing of compliance and enforcement activities, and gaps especially for non-safety related standards."[3]

4.3.2 New Zealand's situation with respect to harmonisation of DER standards is very similar. Individual distributors are required through Part 6 to specify standards and arrangements covering inverter-connected solar PV and BESS but have no clear ability to oblige consumers to adopt standards for EV chargers, which are currently treated like a large appliance.

4.3.3 Nationally consistent standardisation is only achieved if all distributors adopt EEA guidelines, which include a focus on monitoring LV network hosting capacity and forecasting trouble spots.

4.3.4 While not as urgent as Australia, a rapid increase in consumer uptake levels of EVs and DER could quite quickly leave us with significant problems. We consider that regulators should develop clear problem definitions and options for improvement.

3 This summary and the full report are available from https://www.srgexpert.com/publications/review-of-governance-of-der-technical-standards/