ELLISTON POWER CONSULTANTS
LIMITED

Submission on:
Issues Paper—Review of common quality requirements

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Introduction:

This submission is made in support of the Authority's FSR multi-year work programme "to ensure New Zealand's power system remains secure and resilient as the country transitions towards a low-emissions energy system". The issues paper this submission relates to is looking at the review of Part 8 of the Code regarding common quality requirements.

Support for programme: We support the Authority adopting a first-principles approach to reviewing the extent to which the Code's common quality requirements appropriately enable technologies. We note that common quality requirements are made up of both the design and capability of generation technologies, and the design and capability of offtake equipment.

New technologies provide advantages and capabilities: We submit that new challenges to connect low-emissions technologies to the power system can be mitigated to a significant degree by enabling such new technologies, including solid state power supplies, inverter-based appliances, and advanced control capabilities of industrial plant, to connect in a way that utilizes their full capability for coping with a wider power quality specification.

Existing power quality requirements were set historically: We recognize that existing and older technologies have resulted in historical constructs which result in constraints on new technologies. These constructs are likely to obstruct progress in all components of the New Zealand electricity system, including generation, transmission, distribution, and load assets.

Part 8 and Part 6 are subjects of our submission: We present through our submission a number of issues which we believe need to be addressed as part of the review of Part 8 Common Quality Requirements of the Code, and a review of Part 6 in due course.

First principles approach necessary: We believe that a first-principles approach would result in a more coherent set of common quality Code requirements that are fit for purpose, and necessary in order to continue to promote the Authority's statutory objectives as technologies evolve.

Submissions on the specific questions raised in the paper are below.

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Q1 Do you agree with the description of the first common quality issue and that addressing it should be a high priority?	We agree that the first common quality issue relating to frequency is a high priority, albeit in a broader context than the narrow description of this common quality issue within the consultation paper. Our submission is as follows:
Frequency tolerances historically set by electromechanical and other machinery which may be more restrictive than necessary for modern technologies..	The first reason stated in the document for needing to maintain frequency within a normal band is to "avoid equipment that produces or uses electricity being damaged and causing economic loss, and potentially physical harm". We submit that this issue may be further characterised as caused by equipment having been specified to a historic standard for connection to our networks. These historic frequency limits were established due to the limitations of equipment available in the past, with their commensurate control regimes and capabilities. We submit that moving forward, those frequency limits should be reviewed. As a small example, modern power supplies for a myriad of household appliances and industrial equipment in use today are able to operate at much wider frequency tolerances, such as "50 Hz to 60 Hz", instead of being "within 1.5% of 50 Hz".

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Existing equipment fleet designed to historic standards and these standards need to be reviewed..

The second stated reason for maintaining a “normal frequency band” is that “to avoid cascade failure of the power system, caused by equipment disconnecting from the power system in order to avoid damage, which again results in economic loss and potentially physical harm”.

With a higher penetration of inverter-based resources on the network and wider frequency “excursions”, the potential for economic loss and physical harm from legacy equipment disconnecting from the system arises from the fact that they had been designed to operate under narrower frequency ranges specified historically when those equipment were installed. We submit that the appropriateness of these narrower limits needs to be reviewed as part of the work programme, so that a transition pathway looking forward can be initiated.

This would ensure that 20 or 30 years from now, with much more advanced technologies, we are not constrained by power quality standards that were set decades and perhaps even a century ago, to suit equipment that have long since become obsolete, decommissioned, and removed from the grid.

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More inverter-based variable and intermittent generation makes system frequency more variable..	There is expected to be more frequency fluctuations over the 5–10 years. This is expected to affect the New Zealand power system more than other jurisdictions due to the relatively small scale of the system and lower system inertia. However, this issue is seen from the perspective of causing "deviations of frequency outside the normal band". This reinforces the need for the FSR work to investigate whether the historical "normal band" is fit for purpose in the future.
Applicability of frequency keeping duties to a small number of generating assets..	The consultation paper notes that there is an incentive on generation owners to have generating stations that export less than 30 MW, from the requirement that generators larger than 30MW are called upon for frequency keeping duties which affect their generation capacity and hence income. This incentive to be smaller than 30MW indicates a free rider issue. Going forward, with much more distributed generation, the burden of frequency keeping falling on the few generators larger than 30MW would become more inequitable.

Procurement of instantaneous reserves as a common quality management tool is likely to change fundamentally as inverter-based technologies become endemic..	The emergence of a strategy of employing dead bands is understandable for generators larger than 30MW which are caught by the requirements to provide frequency response. By virtue of the speed of response available from new classes of inverter-based equipment which were not in existence when the regulations were implemented, instantaneous reserves can be provided by aggregators harnessing a myriad of small distributed generators and especially battery systems, including grid-scale BESS. The current observed behavior of generators employing deadbands may become only of operational interest. We submit that the FSR work programme should not be distracted by trying to address this behavior but instead look to the future structure of the power system and identify procurement mechanisms for instantaneous reserves in that context.
Q2. Do you agree with the description of the second common quality issue (ie, first voltage-related issue) and that addressing it should be a high priority?	We agree that the second common quality issue relating to voltage is a high priority. Our concern is not described in the consultation document. Our concern is described below:

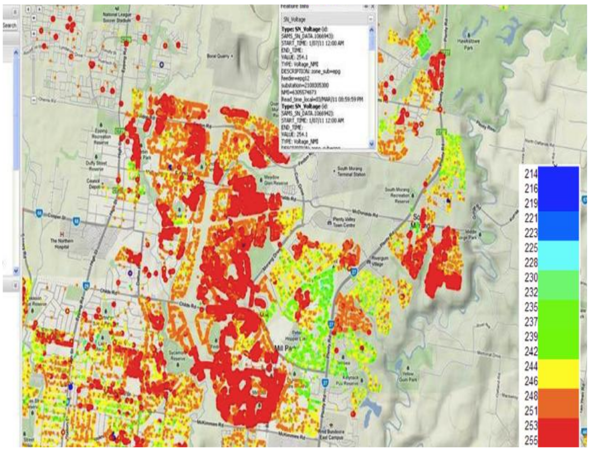
Inverter-based generating systems raises the voltage at the network connection point..

The key voltage issue with more and more inverter-based system relates to the action of the inverters to enable grid feed in.

Power will only flow back into the network if the inverter raises its output voltage higher than that of the grid at the injection point. By doing this, the inverter is able to push power into the network ("water only flows downhill" – power from a PV or battery system will only go into the grid from a voltage higher than that grid).

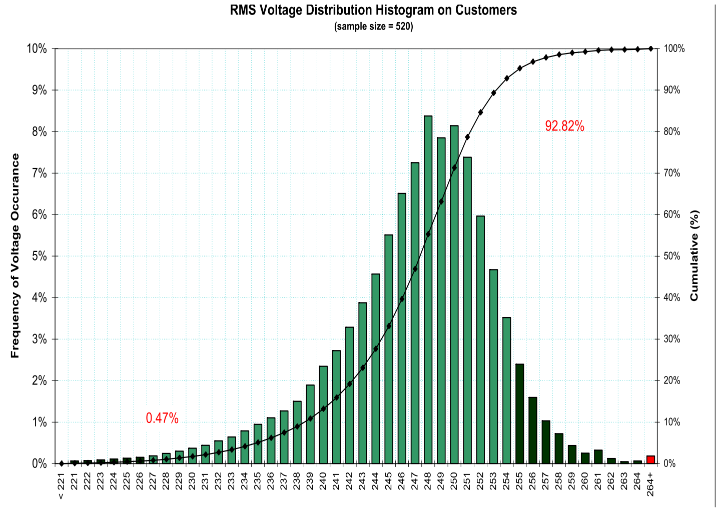
If there are 10 inverter-based generators on a street, the inverter closest to the feeder transformer raises the house voltage slightly above the network at that point. The next inverter raises the voltage higher than the first. The next higher again, and so on. By the 10th inverter in the street, the voltage can be significantly higher than that at the beginning of the street. Every consumer connected to the feeder now experiences higher voltages from the inverters on that street.

Here is a map showing voltages resulting from high solar penetration in suburban Melbourne:



It shows significant points where the network voltage is above 255V, on a nominal 230/240V network.

The information is presented in graphical form as follows:



The significant information here is that the voltage is out of range for significant amounts of time – essentially non-compliant with supply regulations.

With more solar penetration in New Zealand, voltage rise problems on suburban feeders will occur here also.

Key enabler of more distributed generation may be from a review of the voltage of electricity supply to an installation..

In Sapere's report to the Electricity Authority titled "Review of potential security, reliability, and resilience concerns arising from future scenarios for the electricity industry" by David Reeve and Toby Stevenson dated 29 June 2021, there is a section relating to voltage (section 3.4.1.1), specifically the 230V plus or minus 6% statutory voltage limit. The key messages from the report are that:

- "..urban networks were the least able to host large penetrations of solar PV due to voltage management issues"
- "It should be noted that all voltage issues are context-specific and there are still a significant number of city, industrial, and rural connections where it might prove difficult, or costly, to integrate solar PV within the prescribed voltage limits"
- "[Prior analysis 2016] … gives 10 per cent as the limit of solar PV penetration in urban low-voltage networks"

The report notes 4 ways were suggested to improve solar penetration, concluding that:

"Of these the most effective mitigation by far (an improvement from 10 per cent solar PV penetration to 30 per cent) is increasing the statutory limit to 10 per cent, although this has other implications for power system and connected equipment performance".

If increasing the statutory voltage limit to 230V plus 10% results in allowing solar penetration to be 3 times, 300%, than leaving the limit at plus 6%, then this is a hugely significant piece of work that needs to be urgently undertaken.

Inverters must raise the voltage at the point of injection for provision of solar generation into the network. The diagrams above show this effect in operation (with a vengeance).

"The highest priority activity on the FSR roadmap is a review of the common quality requirements to ensure they enable evolving technologies, particularly inverter-based resources, in a manner that promotes the Authority's statutory objectives."

We submit that this is the key issue for the FSR review of common quality requirements on "voltage".

If an increased voltage range enables inverter-based resources to increase 3-fold, we submit that the FSR review extend resources to ascertain the potential benefits of moving the statutory voltage range as a matter of urgency.

Q3. Do you agree with the description of the third common quality issue (ie, second voltage-related issue) and that addressing it should be a high priority?	The second voltage related issue relates to that of network performance issues associated with reduced system strength. This issue does not seem to be a key issue for networks with significant amounts of solar penetration. The emergence of grid-scale dispatchable batteries seems to mitigate the loss of system strength in networks experiencing high levels inverter-based generating assets. If in the future modeling by the system operator identifies that this is becoming an issue, procurement of technology to address any identified problem seems to be an option for addressing this problem. Hence we submit that we do not agree that this should be a high priority issue.
Q4. Do you agree with the description of the fourth common quality issue (ie, third voltage-related issue) and that addressing it should be a high priority?	The third voltage related issue is to do with fault ride through. We understand that this can be addressed through the ensuring the standards being applied to inverter-based equipment connecting to networks specify the required performance including fault ride through capability. We further understand that joint AS/NZS inverter standards recently promulgated by Australian participants facing an acute need for fault ride through has mitigated the problem to some degree.

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	New Zealand can raise its level of contribution if the need arises to address this issue for our operating environment. Hence we submit that we <u>do not agree</u> that this should be a high priority issue.
<u>Q5</u>. Do you agree with the description of the fifth common quality issue and that addressing it should be a high priority?	This issue relates to harmonics. We understand that this can be addressed through various standards. Ambiguity with which standards apply should be resolved. Inverters are already subject to harmonic distortion requirements. When equipment become available to measure harmonics accurately, and when distribution companies are capable of undertaking measurements of harmonic distortion on their networks, exploratory work may then be able to be undertaken to determine the size of the problem. Hence we submit that we <u>do not agree</u> that this should be a high priority issue.
<u>Q6</u>. Not applicable.	
<u>Q7</u>. Do you agree with the description of the sixth common quality issue and that addressing it should be a high priority?	This issue relates to insufficient information on assets wanting to connect. We submit that there needs to be prescribed line items that must be disclosed for assets that want to connect to the power system.

	Items that enable the proper functioning of the power system needs to be identified and rationale for the information required should be clearly articulated. We understand that the information may include real time information where these affect system operations. Hence we agree that this should be a high priority issue.
Q8. Do you agree with the description of the seventh common quality issue and that addressing it should be a high priority?	This issue relates to code terms missing. This is an administrative issue which should be resolved. Hence we agree that this should be a high priority issue.

Q9. Do you consider there to be other high priority common quality issues not identified in this paper that are occurring or that you expect to occur because of:

a. the uptake of inverter-based resources, and/or

b. how the Code enables different technologies?

We have outlined the two main issues we believe are urgent and important to address in the work of the FSR in reviewing the common quality requirements under part 8 of the Code.

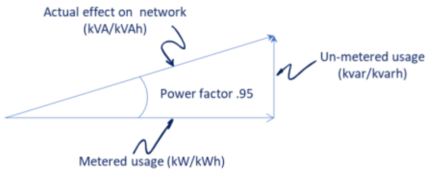
These two issues are:

- A review of the frequency tolerance
- A review of the statutory voltage limits

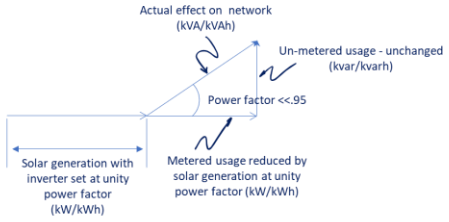
Our reasons for our views are submitted above.

With the uptake of inverter-based resources, we raise the following issue for consideration in any Part 6 review undertaken subsequent to this Part 8 Common Quality Requirements review.

We present an example: a residential premise without distributed generation may have a particular power offtake at an instance in time as follows, assuming it is complying with a power factor requirement of .95 lagging:



If this premise installs an inverter-based generating system today to supply part of its requirements, the above instant may in fact look more like this:



From a power sector perspective:

- this reduces the efficiency of the network as a whole
- it puts a disproportionate burden on the remaining participants in terms of the increased system losses relative to the kW load delivered
- Somebody is paying for the VARs somewhere.

The network is now loaded in a significantly different manner to what would have been contemplated by common quality requirements. The network is not being recompensed for the service it is now called to provide to the premises with a generation system operating at unity power factor: residential consumers are only billed for active power, not VARs/reactive power.

The reduction in efficiency is from that caused by a network designed and priced to provide premises with the regulated 0.95 power factor now providing power at a much worse power factor. The implications of this needs to be investigated urgently, prior to even a modest penetration of distributed generation.

We submit that prior to making it easier to install larger inverter-based resources, the reactive power contribution from these systems needs to specified/prescribed, so that purchasers of such system are aware of the impact that any such requirement will have on the nameplate rating of their distributed generation systems (contribution to VARs reduces the kW output available for offsetting power imports).