20 August 2024

Future Security and Reliability team
Electricity Authority
P O Box 10041
Wellington 6143

Via email: fsr@ea.govt.nz

Dear team,

Re: Consultation Paper—The governance and management of harmonics in New Zealand's power system

NewPower Energy Services Ltd and subsidiary Infratec NZ Ltd appreciates the opportunity to make this submission on the Electricity Authority's (Authority) consultation on governance and management of harmonics in New Zealand's power system.

NewPower is a subsidiary of WEL Networks Limited, New Zealand's sixth largest distributor. NewPower subsidiary Infratec NZ Ltd is delivering low-carbon utility-scale solar and battery solutions at a time of unprecedented growth in New Zealand. Infratec developed and commissioned NZ's first utility scale battery energy storage (BESS) facility at Huntly, connected to WEL Networks' distribution assets. Infratec has also constructed and commissioned approximately 66 MW of utility-scale solar farms connected to distribution networks in New Zealand for clients with an additional 60MW currently under construction. We also commissioned the 4MW Naumai solar farm in Northland in Q3 2024.

NewPower and Infratec agree it is timely to review management of harmonics in the NZ power system. We request that the Authority and System Operator (SO) continue to involve relevant stakeholders (especially generators) in analysing the issues and developing solutions so that any short-listed options for further investigation are practical and achievable. For example, if a generator is emitting harmonics over any regulated limit a pragmatic approach should be able to be taken based on an assessment of the real-world impact of this deviation.

This could be a major piece of work given the date of previous studies and the changing composition of the transmission grid and generation mix. However, the Authority and SO should be prepared to adopt overseas approaches if appropriate rather than 're-invent the wheel'.

NewPower suggests the first stage should be to take nation-wide power quality measurements to understand the 'state of the nation'. There is currently little information, and any proposed changes should be based on up-to-date information.

General comments on consultation paper

More work needs to be done on understanding the cost-benefit trade-offs implicit in a harmonics management framework. The consultation paper concludes that "*it appears reasonable to expect that the cost of harmonics on New Zealand's economy could be material*" based on studies in Europe, North America and Australia that are over 20 years old[1]. Further, the Australian study "*indicated the losses due to poor power quality, especially as a result of harmonics, can amount to* ***several million dollars per annum***" [emphasis added] but this cost must be considered relative to total system costs.

Reference 9[2] indicates the costs of poor power quality are high but the costs related to harmonics are very small as a proportion of power quality costs. The survey data analysed in the paper is close to 20 years old. Technology has moved on considerably in this time; the widespread adoption of LED lighting, inverter drives and switched mode power supplies has changed the demand characteristics of final users across the distribution networks.

From reference 9: Cost of PQ wastage EU-25 by PQ Phenomenon & cost category

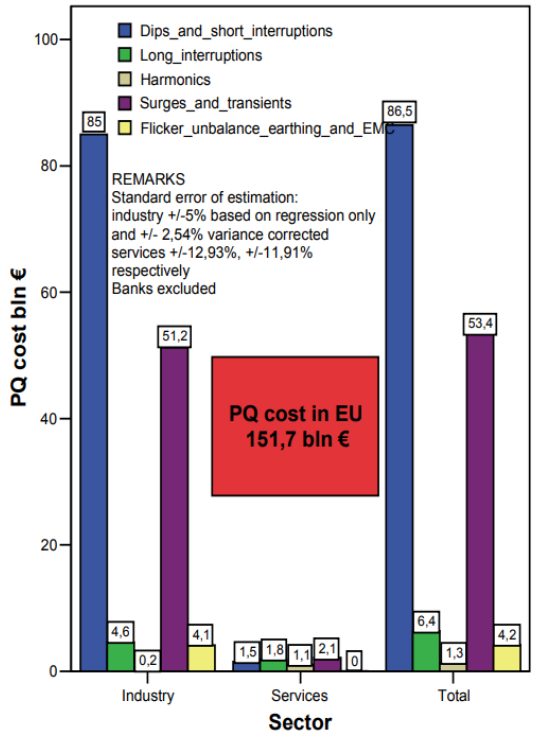
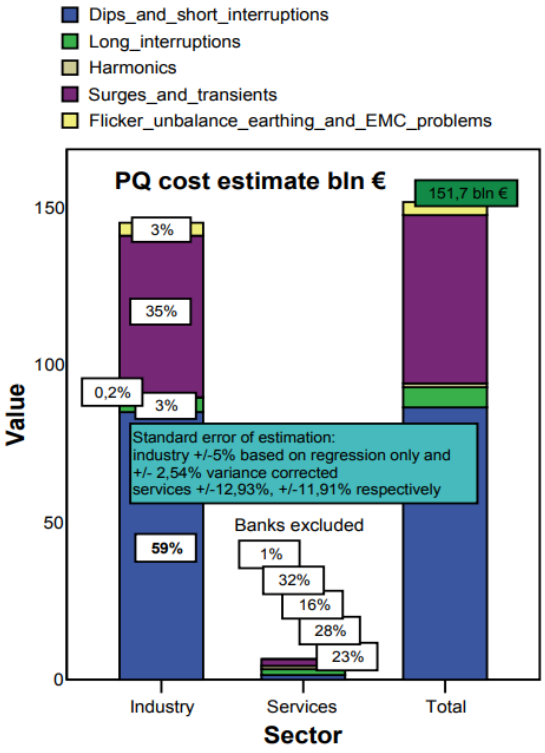


Figure 6. Cost of wastage caused by poor PQ in EU-25: Summary



Likewise, Reference 10[3] uses data that is over 20 years old. The document notes that 69% of all establishments in the DE, CPM, and F&ES sectors report no costs associated with power quality problems in a typical year. For a handful of large and highly sensitive establishments, however, losses from power quality phenomena are significant. Any analysis should consider if it is more

[1] Paragraph 3.9 https://www.ea.govt.nz/documents/5153/Paper_3_The_governance_and_management_of_harmonics_in_New_Zealands_power_system.pdf

[2] PAN EUROPEAN LPQI POWER QUALITY SURVEY, Roman Targosz and Jonathan Manson, C I R E D 19th International Conference on Electricity Distribution Vienna, 21-24 May 2007.

[3] The Cost of Power Disturbances to Industrial & Digital Economy Companies, Submitted to: EPRI's Consortium for Electric Infrastructure for a Digital Society (CEIDS) By Primen, June 29, 2001.

economically efficient to address harmonics at a system-wide level or for sensitive establishments to invest in protection.

The NZ ECP 36:1993 Standard is more applicable to consumers with harmonic emissions that may affect other consumers. There is no justification for the harmonic levels in the Standard. The Standard addresses traditional harmonics problems of the time e.g. problems in electrical equipment and interference with fixed line telecommunications.

One of the concerns with increasing amounts of inverter-based generation and energy storage devices on the power system is that harmonics emissions may cause problems with other inverters leading to a less stable power system. This problem is different to the traditional harmonic problems and may require a different approach.

The 61000 series Standards referred to in the Electricity (Safety) Regulations 2010 Act 61000 seem to apply to low voltage connections:

- IEC 61000–3–2: Limits - Limits for harmonic current emissions (equipment input current ≤16 A per phase).
- IEC/TS 61000–3–4: Limits - Limitation of emission of harmonic currents in low-voltage power supply systems for equipment with rated current greater than 16 A.
- IEC 61000–3–12: Limits - Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current >16 A and ≤ 75 A per phase.

Medium voltage connections for larger DG and DER seem to be covered by NZ ECP 36:1993. We query what Standards apply for distribution or sub-transmission inverters?

Inverter manufacturers have some ability to tailor harmonic current emissions from their equipment. This ability can be used to game any harmonic emission limits in Standards or provide help in in mitigating harmonic problems.

Conversely, looking at how generators and demand customers plan their new installations with regard to seeing how the choice of transformers, inverters and switching frequencies could potentially reduce or limit harmonics and inter effects.

Whilst there are challenges from the increase of IBR, there are also opportunities. Looking holistically at the system, the recent EA consultation papers on voltage and frequency have also highlighted issues with reactive power provision, inertia, short circuit level and harmonics. These are actually all areas that IBR can help respond to, providing VARS, synthetic inertia, reactive fault current, harmonic cancellation etc. Looking at these problems together, there is potential for IBR to be performing multiple tasks at once, especially if there was an incentive given for 'excess' capacity in the IBR to perform these functions where they are in high demand.

This cover letter should be read in conjunction with our response to the Authority's consultation questions in the attached Appendix.

This is a highly technical topic and important issue to address at least cost to New Zealand consumers. NewPower would welcome the opportunity to engage in the detailed analysis that needs to be undertaken to formulate a short-list of options for a least cost solution for the long-term benefit of consumers.

Yours Sincerely,

Darren O'Neill
Product Development Manager
NewPower Energy Services Ltd

APPENDIX: NewPower's response to Consultation Questions

Question	Comments
Q1. Do you consider the Authority has accurately summarised New Zealand's existing key regulatory requirements for harmonics? If you disagree, please explain why.	Yes.
Q2. Do you agree the Authority has identified the main challenges with the existing arrangements for the governance of harmonics? If there are any additional challenges, please set these out in your response	Yes. It is good that the paper identifies the limitations of the existing Standards in their applicability to certain sizes and types of installations. The fact that there may be some conflict between the Code and existing Standards has also been highlighted, which is good. What is still not 100% clear is how the issue of integration of IBRs and their associated harmonics will be fully addressed. We are not clear if any of the Standards specifically address this issue, so it may be something additional that needs further consideration.
Q3. Do you consider the existing regulatory framework for the governance of harmonics in New Zealand is compatible with the uptake of inverter-based resources? Please give reasons for your answer.	No. The existing framework needs to be updated for clarity and to accommodate technology changes. The problem of harmonic issues with IBR needs to be clarified as the issues and mitigations are likely materially different from those of more traditional harmonic issues.
Q4. Do you have any feedback on the Authority's suggested way forward to help address the challenges with the existing arrangements for the governance of harmonics?	There should be stronger clarification of costs and benefits. Should Standards be selected to meet the requirements of the most sensitive parties affected by harmonics or be based on the requirements a more typical connected party? A suggestion may be to develop clear guidelines for stakeholders to aid in understanding and applying whatever Standard(s) are adopted. We request that the Authority and SO continue to involve relevant stakeholders (especially generators) in analysing the issues and developing solutions so that any short-listed options for further investigation are practical and achievable.
Q5. Do you have feedback on any of the elements of good industry practice relating to a framework for managing harmonics? This may include feedback relating to elements you consider are missing	Owners of inverter-based resources need certainty around the likely costs associated with harmonic mitigation that they will be required to pay. There needs to be a process to manage changes in the harmonic characteristics of the network. As a collection of minor changes to the system may have larger effects on

Question	Comments
from the summary provided in section 5 of this paper.	harmonic levels in other areas, there needs to be consensus on how such situations are treated, and how any rectification or mitigation works are funded. There is a need for flexibility around, and pathways for, managing non-compliant plant. Also, there is a need for proportionality in the effort and costs for required harmonic impact assessments. Distributors can be given more certainty of recovery of costs (e.g. as part of RAB) where harmonic problems can be efficiently mitigated by the distributor. Having a centralised database of background harmonic levels would be useful to generators when carrying out harmonics assessments.
Q6. Do you agree with a 'whole of system' approach to allocating harmonics, so that any differences in harmonic allocation methodologies between electricity networks do not cause excessive harmonics? If you disagree, please explain why.	Yes. It is desirable that a similar harmonics allocation approach is applied in each distribution network so that developers will have lower costs in managing harmonics issues. It also makes things more predictable for generators as the same rules will apply across all distribution networks.
Q7. Do you have any feedback on the suitability for New Zealand's power system of the harmonics standard NZECP 36:1993, or the AS/NZS 61000 series of harmonics standards?	NZ ECP 36:1993 is obsolete and needs to be updated or abandoned. The Standard pushes a deterministic approach to compliance (e.g. installations are compliant or not). It is not certain how well the 61000 Standards work series works for MV connected DER. The AS/NZS 61000 series of Standards is more aligned with international standards than NZ ECP 36 and it addresses a wider range of harmonic issues, so it might provide a more robust framework for managing harmonics going forward.
Q8. Do you have any feedback on the alternative approaches to limiting harmonic emissions, including alternative approaches you consider to be appropriate for New Zealand's electricity industry?	Yes. None of the options as described fully solve the expected issues. The open network approach has some good benefits around connecting and responding to actual issues, but managing the network, the generators and the loads would potentially be unmanageable and result in real time problems rather than problems in the planning process. The costs of compliance are removed from the planning stage, but then could be introduced at any stage. Given the potential costs, this could act like the 'Sword of Damocles' for the projects with uncertain costs becoming a barrier to investor backing.

Question	Comments
	Requiring net absorption has a major flaw, in that it looks individually at generators, not holistically at the system. If similar IBR are used (New Zealand doesn't have the biggest range of products for items like central inverters), then it is expected they will have similar performance. There may then be certain harmonics well absorbed by these IBR, and certain harmonics that are exported. All generators may be compliant, but the overall system is suffering at the range that the similar IBR and technologies export at, and any 'easy win' ranges will have excess capacity ie the focus by each generator is to achieve the easiest, cheapest net absorption, not the best system performance. Charging emitters has some benefits, but as with the open approach, could have issues in identifying the emitters / causers and fairly allocating costs to them. Pre-emptive installation of filters will simply act as a barrier cost, and whilst it may be helpful in some situations; there are a number of issues with these filters that are starting to be identified in practice. This looks to be an inefficient use of resources and will consequently halt or slow viable new renewable generators.

20 August 2024

Submissions
Electricity Authority
P O Box 10041
Wellington

Via email: fsr@ea.govt.nz

Dear team,

Re: Consultation Paper—Addressing larger voltage deviations in New Zealand's power system

NewPower Energy Services Ltd and subsidiary Infratec NZ Ltd appreciates the opportunity to make this submission on the Electricity Authority's (Authority) consultation on addressing larger voltage deviations in New Zealand's power system.

NewPower is a subsidiary of WEL Networks Limited, New Zealand's sixth largest distributor. NewPower subsidiary Infratec NZ Ltd is delivering low-carbon utility-scale solar and battery solutions at a time of unprecedented growth in New Zealand. Infratec developed and commissioned NZ's first utility scale battery energy storage (BESS) facility at Huntly, connected to WEL Networks' distribution assets. By way of context for this submission, NewPower is the operator of this new 35MWh rated BESS which will operate within both Network and Grid compliance modes, and so can offer a range of network, transmission and energy market services within NZEM's wholesale market dispatch compliance rules. This BESS is already contracted to the System Operator as an ancillary service agent for instantaneous reserves.

Infratec has also constructed and commissioned approximately 66 MW of utility-scale solar farms connected to distribution networks in New Zealand for clients with an additional 60MW currently under construction. We also commissioned the 4MW Naumai solar farm in Northland in Q3 2024. All generation except the Rotohiko BESS are exempt stations, being under 30MW net export. We have provided detailed Asset Capability Statements to the System Operator (SO) (consistent with the Code). And, despite being below the 30MW net export threshold, have incurred not insignificant costs for each solar farm associated with detailed technical testing by both the distributor and SO both during the design stage and commissioning of these generating stations.

NewPower agrees with the Authority that "*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*". It is important that everyone understands the current and future technical capability of these technologies to deliver reliable[1] electricity. NewPower has been instrumental in upskilling the Electricity Authority and

[1] As defined by the Electricity Authority: "'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).", page 7 of the consultation cover paper https://www.ea.govt.nz/documents/5154/Future_Security_and_Resilience_-_Review_of_common_quality_requirements_in_the_Code.pdf

Transpower (Grid Owner and System Operator) in the operation of New Zealand's first utility scale battery and is open to sharing its expertise about battery and solar technology at any time.

Key points in our submission

In summary, NewPower and Infratec:

1. **does not support Option 1 and Option 2.** An extra interface for distributed generation to the transmission System Operator (TSO) as well as the distributor it is connected to is unnecessary and illogical. The TSO should control to the GXP – that is the point at the end of assets owned and under the control of Transpower – and the distributor, or Distribution System Operator (DSO), control the network that it owns beyond the GXP. Without this demarcation there will be duplication, confusion and potentially opposing instructions and obligations for connected parties. The TSO should send its requirements to the DSO who then applies their own requirements to distributed generation and distributed energy resources (including consumer connected Consumer Energy Resources).

2. have the opinion that the status quo in terms of regulation and distributor best practice is sufficient to manage voltage in distributor networks and at GXPs. Currently distributors have voltage limits on their networks and will manage distributed generation to ensure these limits are not exceeded.

3. have experienced distributors being more restrictive on voltage limits for distributed generation than the voltage limits stipulated by the code for distributors. This can lead to distributed generators improving voltage quality for distributors without compensation and loss of energy generation due to voltage limits. This should be addressed in the upcoming Part 6 code review (i.e. standardised voltage limits should be applied consistently to generation, demand, and distributors control capability)

4. recognises that Option 3 of mandating fault ride through levels for distributed generation less than 30 MW would be beneficial, but the fault ride through limits and curves must be reasonable, realistic and consider typical limitations of different types of generation technology. The fault ride through requirements should be based on faults that occur frequently enough to qualify as contingent events.

Each of these points is discussed in a separate addendum which includes worked examples and our response to the Authority's consultation questions (both containing confidential commercial information).

Yours Sincerely,

Grant Smith
CEO
NewPower Energy Services Ltd

20 August 2024

Submissions
Electricity Authority
P O Box 10041
Wellington

Via email: fsr@ea.govt.nz

Dear team,

Re: Consultation Paper—Addressing more frequency variability in New Zealand's power system

NewPower Energy Services Ltd and subsidiary Infratec NZ Ltd appreciates the opportunity to make this submission on the Electricity Authority's (Authority) consultation on addressing more frequency variation in New Zealand's power system.

NewPower is a subsidiary of WEL Networks Limited, New Zealand's sixth largest distributor. NewPower subsidiary Infratec NZ Ltd is delivering low-carbon utility-scale solar and battery solutions at a time of unprecedented growth in New Zealand. Infratec developed and commissioned NZ's first utility scale battery energy storage (BESS) facility at Huntly, connected to WEL Networks' distribution assets. By way of context for this submission, NewPower is the operator of this new 35MWh rated BESS which will operate within both Network and Grid compliance modes, and so can offer a range of network, transmission and energy market services within NZEM's wholesale market dispatch compliance rules. This BESS is already contracted to the System Operator as an ancillary service agent for instantaneous reserves.

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NewPower agrees with the Authority that "*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*". It is important that everyone understands the current and future technical capability of these technologies to deliver reliable[1] electricity. NewPower has been instrumental in upskilling the Electricity Authority and

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Transpower (Grid Owner and System Operator) in the operation of New Zealand's first utility scale battery and is open to sharing its expertise about battery and solar technology at any time.

Key points in our submission

In summary, NewPower and Infratec:

1. strongly support Option 3 which is to "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". This solution addresses Issue 1 which is only focused on managing "more variability in frequency within the normal band". Procuring more instantaneous reserves will assist with managing contingent and extended contingent events – a separate issue from Issue.

2. recommend the SO reconsider its power systems analysis for this consultation taking into account its recommendation in June 2023 that "a*sset owners looking to connect IBRs greater than 1 MW are recommended to use GFM inverter technology to ensure their asset remain stable following system events".*

3. The Authority and SO review their assumptions about the technical capabilities of BESS to support frequency keeping outside the normal band. In our view, the results and the SO's own studies understate the benefits of BESS.

4. reject Option 1 to lower the threshold of 30MW net export at all and particularly to 5MW. At this initial stage[2] we believe there are inconsistent assumptions in the modelling and our analysis of costs imposed by a lower threshold means costs are very likely to exceed any benefits of this Option, especially when compared with the counterfactual of Option 3.

5. reject Option 2 to introduce a maximum deadband beyond which a generator must contribute to frequency keeping and instantaneous reserves. Our analysis of costs imposed by a 'tighter' deadband exceed any benefits of this Option.

Each of these points is discussed in a separate addendum which includes worked examples and our response to the Authority's consultation questions (both containing confidential commercial information).

Yours Sincerely,

Grant Smith
CEO
NewPower Energy Services Ltd

[2] Referred to as 'initial' given the Authority is asking if the option warrants further investigation.