Tesla Motors Australia, Pty. Ltd.
Level 14, 15 Blue Street
North Sydney 2060 NSW
Australia

Transgrid
180 Thomas St, Haymarket
Sydney
NSW 2000
Via email to: regulatory.consultation@transgrid.com.au

2 August 2024

Dear Transgrid,

RE: Meeting system strength requirements in NSW (RIT-T Project Assessment Draft Report (PADR))

Tesla Motors Australia, Pty Ltd (Tesla) welcomes the opportunity to provide Transgrid with a direct response to the PADR for system strength requirements in NSW (in addition to supporting proponents).

Tesla's mission is to accelerate the world's transition to sustainable energy. A key aspect of this will be using smart, grid-forming inverters to support increased penetration of variable renewable energy (VRE) in the grid. We believe that battery energy storage system (BESS) assets, particularly Tesla Megapacks operating with our virtual machine mode (VMM) technology, will be integral to providing a scaled, cost-effective system strength solution in all Australian jurisdictions.

Tesla is supportive of Transgrid's approach in continuing to explore the viability of non-network options through the RIT-T process. As Tesla detailed previously[1], grid-forming inverters, and BESS assets in particular, provide a solution that can be optimised in the long-term for both market and network services such as system strength – with the main barrier to wide-spready deployment being a lack of familiarity with the technology relative to traditional synchronous assets.

We further believe that non-network battery solutions have the following benefits over the traditional synchronous non-network solutions (i.e. synchronous condensers and synchronous machines) that Transgrid have identified as the preferred option in the PADR, specifically:

1. **Grid-forming batteries are multi-use assets** and provide a multitude of market services as well as network support to make them more cost effective than other solutions. Given the flexibility of BESS to have features and functionality updated over the asset life, these services can also change over time to provide optimal co-benefits to the grid and the market.
2. **Grid-forming BESS assets support the broader NSW Energy Security Target (EST) directly contributing to both reliability and system security objectives** – aligning with complementary policy development work that the NSW Government, EnergyCo. and AEMO Services are managing. Supplementary BESS deployment also aligns with the broader federal priorities under the Capacity Investment Scheme seeking 9GW of dispatchable capacity across the NEM.

In Tesla's view (as supported by independent reports from AEMO, ARENA, and ongoing global studies that Tesla can share on request) grid-forming BESS assets also meet all of the technical characteristics for providing system strength and ensuring a stable voltage waveform – and this performance is now widely demonstrated. It is al so important to note that once grid-forming mode (such as VMM) is enabled at the point of grid connection, then BESS assets will provide ongoing system strength support without any need to respond to external enablement signals. This means that non-network solutions can provide system strength whilst also optimised for market needs at any point in time – performing several different functions simultaneously. This further improves the commercial viability of grid-forming BESS assets as a non-network solution, and removes the justification that synchronous condensers are in fact a 'no-regret' solution – given they provide less value as a single-use, single-purpose asset.

[1] https://www.transgrid.com.au/media/kelpxss5/tesla-submission.pdf

Tesla has mature grid models available for grid-forming Virtual Machine Mode in both RMS and EMT environments which have been the subject to the rigorous assessment under NER 5.3.4A/B and 5.3.9 for NEM connected projects. Tesla has previously worked with Transgrid in delivering the Wallgrove BESS, including the enablement of grid-forming functionality through a 5.3.9 process and believe that this model provides a good base case of what could be provided at scale and should therefore be granted part of the optimal portfolio of solutions as part of the PACR stage.

Notwithstanding the advice from a single consultant through this PADR process, grid-forming batteries are a readily available, off-the shelf solution that can be deployed rapidly at scale, as fast or faster than many alternative solutions and Tesla is capable and willing to support a portfolio of grid-forming BESS assets to meet the system strength requirements outlined in the PADR and support the connection of 15GW of VRE in NSW. Accordingly, we recommend Transgrid re-consider its advice that: *"there is insufficient evidence (either at-scale deployments or in modelling) to rely on grid-forming BESS to support minimum fault level requirements (until 2032/33)."*

Rather, **Transgrid should affirm its ambition to become a future-focused and innovative TNSP to bring together leading engineers, regulatory experts, and commercial teams to outline a clear pathway for grid-forming batteries to be address these perceived barriers** – i.e. to use this RIT-T process as an opportunity to conduct detailed modelling and support additional 'at-scale' deployments that will provide the confidence that is being sought for a "satisfactory fault current response to enable the safe (and successful) operation of protection equipment in the transmission network". We recommend this work be done in parallel with AEMO and ARENA who have spend several years working on multiple grid-forming BESS projects together with proponents and have an independent, yet detailed understanding of the capability, strengths, and existing gaps of the technology.

We understand the need for a risk-averse approach as a network operator to ensure safe and secure grid operation, but given the size of the opportunity identified through this RIT-T, it would be short-sighted to overlook a technology, such as grid-forming BESS, that is at the cusp of technical acceptance with network engineers simply due to unfamiliarity, without first seeking to fully address the unknowns through additional studies and technical due diligence together with technology providers such as Tesla.

As a useful precedent, we point to the approach taken by the Victorian Government that had originally allocated its system strength funding only to synchronous condensers, before also allowing grid-forming battery projects to tender alongside – with the Koorangie BESS contracted for system strength services.

Further background on the points raised above is provided below.

Kind regards,

Dev Tayal

Tesla – Policy

atayal@tesla.com

1. Context

To date, battery storage has been mostly recognised for the value it provides in managing frequency stability and restoration - providing premium contingency and regulation frequency services across the NEM since the introduction of Hornsdale Power Reserve in 2017. However, as familiarity with power electronics and grid-forming inverters grows, we encourage Transgrid to embed a future focused approach that also recognises the value that 'non-synchronous' assets such as grid-forming battery storage can provide in terms of positive contribution to system strength, voltage stabilisation and inertia.

Recognising these aims go beyond this single RIT-T, Tesla continues to engage the AEMC, AEMO, AER and other TNSPs to support formalising a more appropriate definition of system strength that focuses on voltage waveform stabilisation, rather than relying on measurements limited to fault current levels.

2. Regulatory Enablers

Tesla notes that to drive wholesale change to the process and timeliness of NSP investment decisions, new regulatory investment test (RIT) frameworks are needed to facilitate non-network options such as BESS, before the system strength guidelines can be successfully applied. However, this does not preclude Transgrid using its position as a leading voice amongst TNSPs to progress non-network options in the near term. Through a combination of regulatory reform and commercial innovation, we believe these barriers can be readily overcome, and rather than default to 'wealth transfers' between multi-use assets such as BESS, Transgrid can work with proponents to ensure economically rational outcomes are progressed. For completeness, we include our summary of RIT issues and barriers below:

1. The RIT is no longer fit for purpose – the process takes far too long to be practical, and the current application of the 'total economic cost' framework fails to recognise today's technology and commercial models. We recognise the attraction of drawing on existing regulatory frameworks, but there are major costs associated with doing so.

2. Non-network options remain consistently undervalued in the RIT-T framework. To Tesla's knowledge, there have been no successful non-network solution projects completed under any RIT-T to date without requiring external funding arrangements (e.g. ARENA or Government grants)[2]. This is because the RIT-T fails to value the full suite of benefits BESS provide, and forces a total economic cost approach that inflates their cost relative to alternatives.

3. Even if the new system strength rules recognise the capabilities and benefits of grid-forming BESS providing system strength services, network companies may face additional barriers in valuing these benefits based on the RIT assessment guidelines, undermining the scheme's benefits: delaying the connection process, unfairly disadvantaging the value proposition of BESS, and adding unnecessary costs to the total system (with less efficient solutions ultimately progressed). These barriers would also frustrate the proposed interlinkages with the UCS and SSM.

4. Whilst broader than this single RIT-T, the AEMC must expedite work with the AER to update all RIT-T guidelines and frameworks that currently impose barriers for non-network options, to ensure the full benefits of an efficient system strength rule change can be captured. Alternatively, the new system strength framework should avoid deferring to the RIT-T until it is fit for purpose. This will have positive flow on effects for all future network led investments, driving more efficient expenditure and lowering costs for all consumers.

[2] We note Transgrid is currently progressing processes to procure non-network services from battery storage systems in Parkes, North West Slopes, and South West NSW – although it remains unclear the reliance of external funding sources for these preferred projects

5. State governments are already implementing bespoke frameworks to circumvent these issues – e.g. National Electricity (Victoria) Amendment Act 2020; NSW Transmission Efficiency Test – which risks inconsistent and disjointed investment frameworks if the RIT isn't updated quickly.

Without new RIT frameworks, there will be a disconnect between the efficient outcomes of the system strength rule change, and the ability for network providers to assess and select non-network solutions as preferred options for providing system strength.

Non-network option barriers in RIT-T

OPTIONALITY

- Part of framework but benefits rarely captured
- Key part of value proposition for non-network options relative to network assets - rapid deployment, modularity (scale up or down)
- Flexibility increasingly important with uncertainty in load and generation forecasts increasing due to transition

MARKET BENEFITS

- BESS proven ability to reduce prices in wholesale energy and FCAS markets
- Benefits excluded due to being 'wealth transfers', but this ignores benefits from improved liquidity and/or the removal of price distortions
- Likely reduced costs on other parties and consumers (e.g. back-up plant directed on)

ANCILLARY SERVICES

- Battery storage projects see most value realised in FCAS markets
- RIT-Ts typically only model wholesale energy changes occurring in dispatch - considering FCAS a negligible class of market benefit
- Unclear how ESS and system strength would be captured

COST ASYMMETRY

- Battery storage can provide multiple services to multiple parties (system strength + energy, FCAS, inertia, FFR…etc)
- AER's guidelines enforce 'total capital cost' is captured, regardless of ownership
- However, this is not balanced by 'total benefits' also being captured – so BESS severely disadvantaged

3. **Improving Assessment of grid-forming inverters**

Tesla continues to seek greater clarity on how NSPs and AEMO will define system strength in the rules and associated guidelines, given current methodology to be used in calculating System Strength Locational Factors (SSLFs) refers to, *"must be representative of the impedance between the connection point and the applicable system strength node, and use available fault level as the basis for the methodology"*, and how this is intended to align with the criteria for a stable voltage waveform in practice. In other words, more detail on how the new standard also known as the 'efficient' level of system strength will be applied to grid-forming inverters, noting it "*can be met by any means, not limited to fault level"*.

Ideally, AEMO can propose a methodology which also accounts for actual grid impedance and essentially differentiates between "low impedance & low short circuit systems" vs "high impedance & low short circuit systems". In general, Tesla believes the proposed voltage and angle sensitivity indices would be a better indicator relative to SCR. This should also resolve lack of confidence Transgrid received from consultants in regards to system strength from purely a 'fault current' perspective.

In addition, we are support of AEMO to establish a protection only minimum short circuit-level guidance so that "controls" (ie Grid forming inverters) and protection short circuit MVA can be segregated. The underlying assumption of SCR=3 is applicable to the grid following inverter. Protection remains an independent issue and industry would benefit from having AEMO treat it separately.

4. Tesla’s Virtual Machine Mode

Tesla offers Virtual Machine Mode (VMM) as a feature on Tesla inverters that mimics the behaviour of a traditional rotating machine. The VMM component runs in parallel with the conventional current source component. The virtual machine is a blended mode that brings dispatchability of a current source operating in parallel with the stability benefits of a voltage source.

Like more traditional inverters, under stable system conditions, the inverter's behaviour is driven by the current source component. The inverter charges and discharges in accordance with commands received from the operator. If there is a grid disturbance, the rotating component responds by producing a reactive current in response to changes in voltage and producing an active power response proportional to the rate of change of frequency (RoCoF).

Though these features can be provided by current-source inverters in response to a predefined feedback control mechanism, the rotating component in Tesla's batteries can respond on a sub-cycle basis – responding to phase angle changes (within 10ms) rather than root-means-squared (RMS) values (within 150ms) – mimicking the electromagnetics of a synchronous generator, but with the additional benefit of flexibility and configurability of the response.

5. Existing Grid-forming Battery Projects

To date, Tesla has supported several grid-forming inverters connect to the NEM through both the S5.3.4A and S5.3.9 connection processes including:

- Neoen Hornsdale Power Reserve: 5.3.9 connection approved using VMM - Tesla’s role as OEM and lead grid modeller has been integral to the successful trial and implementation of Virtual Machine Mode (VMM) for inertia services at Hornsdale Power Reserve in South Australia. A comprehensive test plan was developed by Neoen and Tesla, in collaboration with ARENA, AEMO and ElectraNet, including the incorporation of an extensive knowledge sharing plan.
- Edify Riverina BESS: 5.3.4A connection approved using VMM - , Tesla supported Edify and its consultants DIgSILENT in preparing a 5.3.4.A and 5.3.4.B application to enable VMM on the 150MW battery at Darlington Point to improve system strength on that part of the network.
- Neoen Victorian Big Battery (VBB): VMM is currently being enabled via 5.3.9 modification (with support from ARENA advanced inverters funding program)
- Lumea Wallgrove Grid BESS – in partnership with Transgrid, Tesla supported the implementation of VMM for inertia at the Lumea Wallgrove Grid Battery by engaging with TransGrid as Network Service Provider and Lumea’s consultant Manitoba Hydro and tailoring learnings for AEMO and NSW Government’s proposed REZ access standards.

Through these experiences, Tesla continue to build knowledge and understanding across industry and stakeholders more broadly, and welcome ongoing work with Transgrid as part of this RIT-T process to develop effective system strength instruments to build on these learnings and capture developments in technology capabilities.

Further, we note that almost all utility scale BESS projects Tesla is currently supporting through grid-connection are looking to register as grid-forming inverters – providing further evidence of technology capability.

6. Expected project delivery timelines

All Tesla Megapack inverters have VMM mode available and connected as grid-forming. For all projects using Tesla Megapacks, these can be grid-forming from the point of connection, with no additional hardware upgrade requirements.

System strength from grid-forming inverters can be provided with no head or foot-room reservation and, in respect of Tesla Megapacks, with no need for additional hardware. This makes it a cost-effective alternative to synchronous condensers.

7. Evidence of technical maturity

Technical maturity

Tesla has conducted a self-assessment against all elements of the AEMO Voluntary Specification for Grid Forming Inverters and confirm that we satisfy all requirements.

Since VMM has now been operational at several BESS sites, Tesla has started to collect a wealth of data during real-world events which is then used to validate Tesla models:

- Figure 1: Tesla VMM responding to a grid frequency event on 11 August 2022. Grid frequency was observed below 49.8Hz with peak ROCOF of -0.09Hz/s. BESS provided a combination of inertial response + sustained frequency response (as expected)

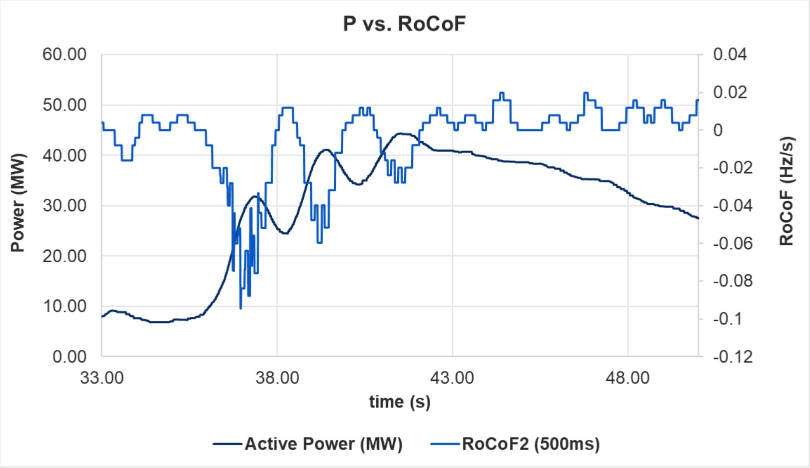


Figure 1: VMM response to 11 August 2022 event

- Figure 2: Tesla VMM responding to a grid frequency event on 11 August 2022. PSCAD model aligned closely with measured performance (see figure top right)

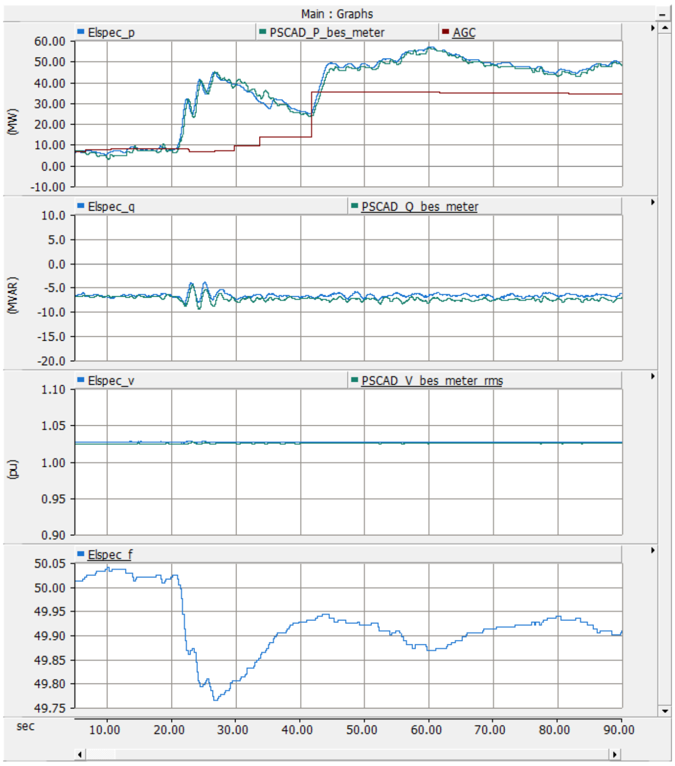


Figure 2: VMM response to 11 August 2022 event

- Figure 3 shows the difference in wave-form response of two Megapacks operating with and without VMM enabled.

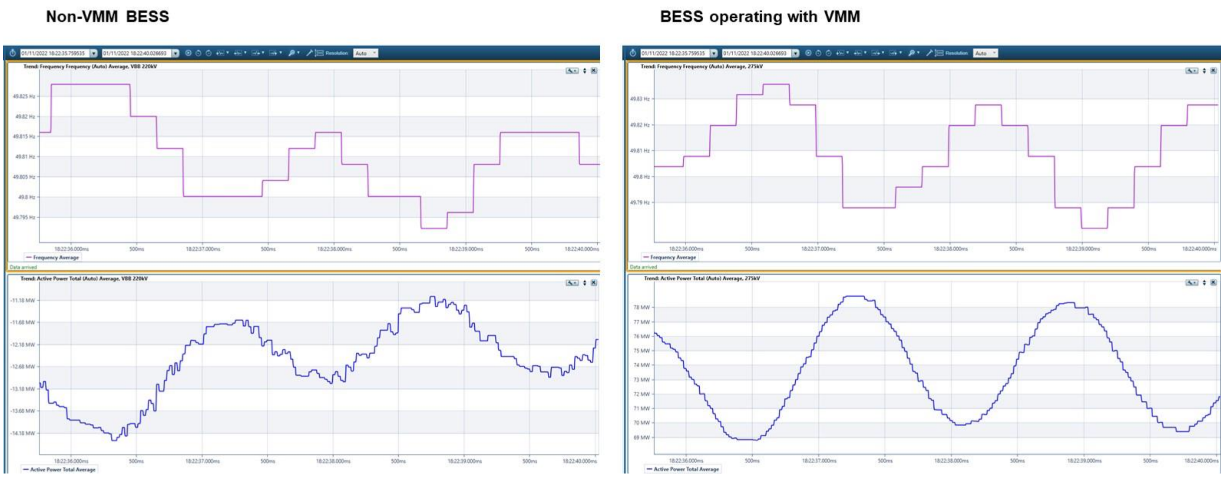
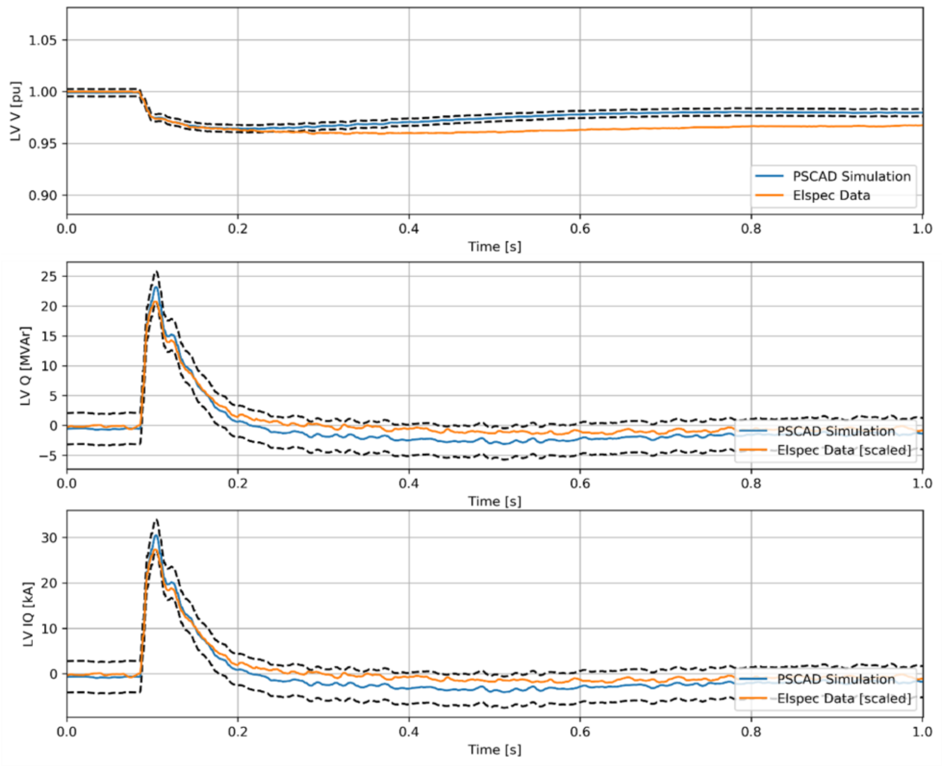


Figure 3: Difference in waveform with and without VMM

- Figure 4 shows the voltage disturbance response. Specifically it shows the following validation:
  - Plant performance is sufficiently consistent with simulation model prediction of behaviour for external voltage disturbances
  - Forced voltage disturbance and corresponding VMM reactive power response is clearly discernible from noise
  - The generating system is capable of continuous uninterrupted operation in accordance with S.5.2.5.4



Inverter level VMM response to external voltage disturbance (scaled)

Figure 4: Inertia level VMM response to external voltage disturbance (scaled)