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Australian Energy Market Commission
PO Box A2449
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23 June 2022

**RE: AEMC Reactive Current Standards for IBR: Consultation Paper – Tesla response**

Dear Ashok

Tesla Motors Australia, Pty. Ltd. (Tesla) welcomes the opportunity to provide a response the AEMC's Efficient Reactive Current Access Standards for Inverter Based Resources – Consultation Paper (the Consultation Paper). We recognise the important role battery storage systems can play to support the NEM's transition, aligning with Tesla's mission to *accelerate the world's transition to sustainable energy,* and are motivated to support AEMCs assessment of new access standards for IBR. We look forward to continuing to work with AEMC, AEMO and TNSPs to facilitate streamlined connection of battery storage, and specifically, to address existing barriers faced by grid-forming (advanced) inverters.

We remain highly engaged in the development of all NEM frequency, system security and system strength reforms, and associated access and connection standards and requirements, and believe they will play an important role in unlocking the integration of storage at scale to underpin a reliable, secure, and affordable electricity system. We commend AEMC's vital role in removing barriers and introducing new markets and mechanisms to support the transition. As a global leader in clean energy products and the largest provider of battery storage systems across Australia, Tesla remains focused on working with all stakeholders to help create clear and fit for purpose market rules and instruments, including efficient access standards.

The following note outlines Tesla's response to relevant questions raised in the Consultation Paper. **Tesla supports the wind-turbine OEMs position on the inappropriateness of overly specifying asynchronous requirements in clause S5.2.5.5, with related barriers (S5.2.5.13 and S5.2.5.15) for grid-forming inverters also outlined. We recommend AEMC ensure the Minimum Access Standards (MAS) move to become outcome focused,** rather than attempting to be prescriptive for different technologies. We also recognise and support the Connection Reform Initiative proposal for S5.2.5.5 MAS.

These observations are based on our experience designing and deploying over 1GWh of grid-following and grid-forming battery storage systems across the NEM to date, including the 50MW/75MWh Wallgrove Grid Battery project; and the expanded 150MW/194MWh Hornsdale Power Reserve – both trialing Tesla's Virtual Machine Mode (VMM) grid forming inverter capability. Tesla has also been selected by Edify to build a 150MW/300MWh battery at Riverina, which will include grid-forming inverters from the outset. The wealth of operational data that Tesla continues to build should provide confidence in our capabilities to meet and demonstrate the technical capabilities required from IBR.

Noting the highly technical nature of this consultation, we would also welcome the opportunity to workshop any of the points raised in our submission, and would look to include our experienced in-house power systems engineering teams in discussions to clarify and expand on any areas of interest to AEMC.

Yours sincerely,

Josef Tadich
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## ONGOING PROCESS

As noted above, Tesla remains highly engaged in the development of all NEM frequency, system security and system strength reforms, and recommends an overarching long-term strategy tying these processes together in order to underpin a secure transition (i.e. requisite system strength, inertia and frequency requirements) to achieve 100% VRE penetration. This will be vital not just as part of AEMC's reform agenda or AEMO's detailed engineering framework and ISP work, but also ensuring NSP requirements and standards and related NER clauses are updated by the AEMC and are complementary to this vision.

In particular, Tesla recommends AEMC (working with AEMO as relevant) provide a clear pathway for grid-forming inverters to provide not just system strength, but other critical grid services. As part of this, Tesla recommends the market bodies:

- Consider extended performance data from HPR, Wallgrove, and other systems that are operating with advanced inverters. With a detailed assessment and comparison to equivalent synchronous condenser performance to cement confidence in the capabilities of the technology for all stakeholders.
- Builds in learnings from both the Victorian RDP process (and potentially ongoing projects) and the ongoing ARENA Large Battery advanced inverter funding round.
- Ensures upcoming inertia, reactive current requirements, and PFR rule changes further build on these learnings.

Lessons learnt will provide opportunities to implement and streamline the connection process for future advanced inverter projects, including the opportunity to progress 5.3.4A/B directly, eliminating the need for a separate 5.3.9 modification application to better enable advanced inverter functionalities.

Through Tesla's experience we continue to build knowledge and understanding across industry and stakeholders more broadly, and welcome AEMC's consultation process to build on these lessons and capture developments in technology capabilities.

### Overview of barriers to Grid-forming Inverters

Updating and developing fit for purpose Access Standards will be critical to accelerate the demonstration of advanced inverter capabilities, overcome existing barriers, and improve industry understanding to accelerate deployments. Currently, developers are hesitant to explore grid-forming inverters given the additional complexity to connect (i.e. higher costs, longer time).

In particular, if connecting in a weak part of the grid, projects are likely to consider traditional synchronous solutions over grid-forming inverters (despite commercial benefits of battery systems) purely to mitigate the additional uncertainty of connection risks or assessments processes.

Storage proponents **need more confidence in a streamlined connection process for advanced inverter capabilities**, given the connection process is already the key bottleneck for projects. We believe with a few adjustments, the NEM's MAS can be updated to achieve this aim.

Notably, an unintended consequence of the current Rules (i.e. the access standards in Schedule 5.2 for asynchronous generation) is that a project with grid-forming inverter technology is assessed against access standards that appear more suited to asynchronous generating systems that are of a grid-following nature, which can trade-off some of the benefits offered by advanced inverters. Ideally the Rules would promote these grid-forming technologies and encourage targeted system strength capabilities that actively support grid stability with high levels of IBR, delivering more beneficial outcomes for the power system overall.

For example, Schedule 5.2.5.5 has alternative pathways for synchronous machines compared to inverter-based resources (IBR) – defined as ‘asynchronous generating systems’. There is significant benefit if Advanced Inverters could be assessed under the synchronous machine pathway (or a hybrid of the two), which can provide desirable overall characteristics.

**Related barriers in the Rules**

Beyond the specific clauses raised in the Consultation Paper, Tesla provides additional commentary on clauses in the Rules that have the potential to limit the benefits of grid-forming inverters based on Tesla’s experience, summarised in the table included below, and aligning with the 12 topic areas as referenced in the consultation paper. As outlined above, we welcome the opportunity to discuss these comments in more detail at AEMC’s convenience.

Table 1:

| Topic | Questions | Tesla comments |
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| **1 ASSESSMENT FRAMEWORK** | Do stakeholders agree with the proposed assessment framework? Alternatively, are there additional principles to take into account or are there principles included that are not relevant? | Tesla agrees with the proposed framework, but notes the consultation should expand its scope beyond just reactive current fault-response MAS, and consider the wider suite of MAS that may be inhibiting or preventing inverter based resources and in particular grid-forming inverters from integrating into the NEM.<br><br>**Recommendation: Tesla supports the wind-turbine OEMs position on the inappropriateness of overly specifying asynchronous requirements in clause s5.2.5.5, and also raises related barriers for grid-forming inverters**<br><br>**Accordingly, we recommend AEMC make a 'preferable rule' to ensure the Minimum Access Standards move to become outcome focused, rather than attempting to be prescriptive for different technologies which is unnecessarily increasing costs for consumers with lower system security.** |
| **2 PROBLEM DEFINITION – SECURITY AND RELIABILITY** | Are the current standards efficient? If current standards are too onerous, what impacts are the reactive current capability standards having on the viability of new resources connecting to the system? Can these impacts be quantified?<br><br>Can the impacts of the reactive current standards on system security be quantified? If not, under what specific circumstances do the coordination challenges presented by too much reactive current capacity create system security risks?<br><br>What implications might emerging technologies have for existing reactive current capability standards? What are the cost and regulatory complexity implications of emerging technologies providing reactive current to support voltage stability? | Tesla views the current standards as inefficient and overly onerous – and as above, recommends MAS adapt to become outcome focused and recognises the different capabilities and characteristics of inverter-based resources relative to traditional synchronous plant.<br><br>We agree with all issues raised in the consultation paper, particularly by the wind turbine OEMs and have observed and experienced similar issues for connecting battery storage in the NEM over the past 5 years. Also strongly support the rationale and highlighted benefits of addressing these issues - which would facilitate integration of all inverter based resources, including battery storage. Accordingly we believe the changes to the NER are justified and positively support the criteria of improving security and reliability, minimising cost, enabling efficient risk allocation whilst preserving competition, and improving transparency and simplicity.<br><br>From a market impact perspective, AEMO forecasts up to ~18GW of storage is required by 2030 (roughly a 6x from today's installed levels); expanded to beyond 50GW by 2050 (a 20x). This will support a near 100% renewable system, meaning the provision of system security will need to be from IBR including battery storage with grid-forming inverters.<br><br>However, if connecting in a weak part of the grid, projects may still be driven to consider traditional synchronous solutions over grid-forming inverters (despite commercial benefits of battery systems) purely to mitigate the additional uncertainty of connection risks. A synchronous condenser and Tesla's grid-forming inverter can have the identical behaviours. But the current rules prohibit the right behaviours from a grid-forming inverter because it must be classified as an asynchronous generator. |

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| | | **This is not aligned with the NEO and creates unnecessary costs for consumers as well as increases system security risks as potential providers of services are delayed / disallowed by the connection process.** |
| **3 PROBLEM DEFINITION – RISK ALLOCATION** | Is the current allocation of responsibilities between NSPs and generators for providing voltage support services maximising system security benefits across the power system?<br><br>If the current allocation is inefficient, what impacts or costs are current arrangements placing on generators' or network businesses' abilities to ensure a secure system at least cost?<br><br>Can competition drive meaningful innovation that will reduce the cost of delivering voltage support services over time? | No. Per response above, the current process and MAS are driving inefficiencies.<br>Battery storage is a flexible asset that can be deployed, owned and operated by different stakeholders depending on the use case.<br><br>However, if the access standards continue to limit the ability for grid-forming inverters to connect, this will drive an inefficient outcome for NSPs to procure single-use technologies such as synchronous condensers, or worse, expect individual generators to procure these assets and increase risk of duplication of investments on the network and generation side.<br><br>We support the premise that competition can be used to drive innovation and reduce costs, but **this can only work if MAS are set appropriately and barriers to innovative technologies are removed first.** |
| **4 GRID APPROVALS** | What problems are the existing minimum access standards on reactive current presenting for more transparent and simple grid approvals?<br><br>Can the cost of these problems be quantified in terms of the typical amount of time it currently takes for grid approvals and how much faster it could be if the Rules were simpler? | Tesla agrees with challenges raised by the wind OEMs – i.e. access standards are challenging to demonstrate compliance with. |
| **5 DETERMINING FACTORS** | What factors should guide the Commission's assessment of how to determine the reactive current capability standard that should apply to inverter-based generation?<br><br>What are the implications of limiting the minimum reactive current response capability that inverter-based generators have to provide, to the relationship proposed by RER in Table 1? | The reactive current response rise time should be defined at the inverters' terminal where the disturbance is detected. The reactive current response settling time requirement should be eliminated or replaced with damping capability (e.g., damping ratio). In addition, the performance should be assessed based on the voltage and current waveform (the ground truth) instead of RMS quantities; different RMS calculation methods can produce very different outcomes.<br><br>Supplying excessive reactive current under low SCR network conditions can lead to instability. Not necessary the more the better. Tesla agrees that the maximum reactive current should be determined based on X/R ratio. This will allow more realistic settings to achieve better overall power system stability. |
| **6 MAS** | If the point of compliance remains at the connection point, at what level should the minimum reactive current capability that generators have to install be set? | Tesla supports a relaxation of performance requirements (e.g. Capacitive reactive power with respect to active power; and Inductive reactive power with respect to rated active power level) |

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| | What potential risks to system security are there from lowering the minimum reactive current capability to this level?<br><br>What are the potential benefits for reliability and efficient investment in generation from lowering the reactive current capability? | If the point of compliance remains at the connection point, the performance requirement should be established based on the impact to the power system. For example, comparing the voltage recovery time with and without the connecting generator.<br><br>Tesla does not foresee risks to the system security from lowering the minimum reactive current capability if the requirements are outcome focused.<br><br>The proposed amendment would enable cost-effective solutions. |
| **7 ALIGNMENT WITH SYSTEM STRENGTH** | To reduce the risk of investment duplication, should the minimum level of reactive current capability take into account the available / forecast level of dynamic voltage support from System Strength Service Providers?<br><br>What are the potential implications for the future development of grid forming inverters from lowering the minimum reactive current capability that inverter-based generators have to provide? | Yes, Tesla supports this rule change aligning with work underway to expand the ability of NSPs to procure system strength from different providers.<br><br>Ideally, AEMC can (working with AEMO's system strength implementation team) 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.<br><br>In addition, AEMC should also work closely with AEMO's system strength implementation 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. Protection remains an independent issue and industry would benefit from having AEMO treat it separately and provide further guidance on this point. |
| **8 POINT OF COMPLIANCE** | What are the distinctions between steady-state compliance and dynamic response that the Commission needs to consider in assessing whether to change the point of compliance assessment from the connection point to the generator unit terminals?<br><br>What specific implications does this have for the connections assessment process and does this outweigh the cost of high-speed monitoring that is needed at each unit terminal to assess compliance? | If control must be at point of connection, it must be site level control. This includes a Power Plant Controller polling a meter and then communicating a setpoint to the generating units. |
| **9 VOLTAGE TRIGGER RANGE** | What are the implications for generator connection applicants of maintaining the rule that the response be triggered at a range of connection point voltages?<br><br>What other implications might lowering the minimum reactive current capability that generators are required to provide have for the voltage level or range that triggers a generator's reactive current response? | **Tesla does not support a mandate to provide power oscillation damping (POD).** A grid forming inverter naturally provides damping capability, therefore a POD requirement should be excluded for grid forming inverters.<br><br>Tesla recommends that S5.2.5.13 should be subjected to full NEM case rather than the case of Single Machine Infinite Bus (SMIB) (with unrealistic Available Fault Level) to set the plant voltage control requirements. |

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| **10 RISE & SETTLING TIME** | What stakeholder experiences over the past three years support a Commission decision to revise the current rise and settling time access standards?<br><br>What should the rise and settling time be revised to if the point of compliance assessment is maintained at the connection point instead of the generator unit terminals?<br><br>How should the rise and settling time standards change with the minimum reactive current response capability, if at all? | Beyond the specific system strength instruments, Tesla observes that an unintended consequence of the current Rules (notably the access standards in Schedule 5.2 for asynchronous generation) is that a project with grid-forming inverter technology is assessed against access standards that appear more suited to asynchronous generating systems that are of a grid-following nature, which can trade-off some of the benefits offered by advanced inverters. Ideally the Rules would promote these grid-forming technologies and encourage targeted system strength capabilities that actively support grid stability with high levels of IBR, delivering more beneficial outcomes for the power system overall.<br><br>For example, Schedule 5.2.5.5 has alternative pathways for synchronous machines compared to IBR – defined as 'asynchronous generating systems'. There is significant benefit if Advanced Inverters could be assessed under the synchronous machine pathway (or a hybrid of the two), which can provide desirable overall characteristics.<br><br>**Tesla recommendations: That a grid forming inverter be assessed under the S5.2.5.5 requirements for "Synchronous generating systems"** |
| **11 MAS CLARITY** | Is there a conflict between the obligations for active power recovery after fault clearance to ensure stable frequency levels and the obligations in S5.2.5.5 for active power to recover to 95% of pre-fault levels after a fault occurs?<br><br>How should this conflict be clarified to ensure clarity on generators' obligations to return to continuous uninterrupted operation in a timely manner? | Agree. There is a conflict between the obligation for active power recovery to ensure stable frequency level and the obligation to recover to 95% of pre-fault levels after a fault occurs. For example, there can be an over-frequency event which requires the battery to reduce the power output or an under-frequency event which requires the battery to increase the power output.<br><br>**Recommendation: The active power recovery time requirement should only apply after the frequency measured at the connection point is returned within the frequency control deadband.** |
| **12 IMPLEMENTATION** | How quickly should any new access standards come into effect?<br>What are the potential unintended consequences of bringing these into effect immediately (e.g. for new connection applications)?<br>What are the implications of providing project proponents the option to connect under the existing or the new standard (e.g. for advanced projects that have already been approved or close to securing grid approvals)? | New MAS should be immediate – as noted giving connection applications the choice to move to new, more 'fit for purpose' standards will be a welcome relief for all stakeholders and will accelerate benefits and minimise risk and costs in line with the NEO. |