July 15, 2021

Shri Sanoj Kumar Jha
Secretary - Central Electricity Regulatory Commission

Re: Comments of Tesla India Motors and Energy Private Limited on the Central Electricity Regulatory Commission Ancillary Services Regulations Draft (No. RA-14026(11)/3/2019-CERC)

Dear Mr. Secretary,

Tesla India Motors and Energy Private Limited (Tesla) welcomes the opportunity to provide a submission to the Central Electricity Regulatory Commission (CERC) Draft Ancillary Services Regulations (Draft Regulations).

Tesla's mission is to accelerate the world's transition to sustainable energy. In this capacity, Tesla is a global manufacturer of advanced electric vehicles, battery energy storage systems, solar photovoltaic systems, and a suite of battery optimization software solutions including autonomous control software for ancillary services participation by batteries interconnected to the bulk electric system, and for distributed solar and battery systems integrated into local electric utility networks. Tesla's unique business model includes the application of its battery storage expertise and production capacity from its vehicles business, to support rapid-scale development of energy storage and solar systems for residential, commercial, and industrial customers. Accordingly, Tesla advocates globally for policies which ensure available and evolving renewable energy and battery technologies are quickly incorporated into energy market designs and incentive structures to secure the stable operation of transitioning energy systems.

Tesla commends the Commission for taking this important step in detailing proposed rules, requirements and payment mechanisms for Ancillary Services and mapping out a proposed pathway to create a fit-for-purpose technical system framework to underpin safe, secure, and reliable operation of the Indian electricity market in the decades to come. As such, Tesla is fully supportive of the objectives of the Draft Regulations. As these requirements become finalised, we provide the following points for the Commission's consideration:

- Tesla fully supports guideline updates that recognize the capability of new technologies, such as grid-forming battery storage systems, to provide the full suite of Ancillary Services across all timescales (primary, secondary, tertiary) and removal of barriers, such as conservative 'sustain' requirements

- Tesla supports inclusion in the guideline of all grid services (ancillary and system integrity protection) which grid-forming batteries can provide, including fast frequency response, inertia, black-start, system restart and re-synchronization, system integrity protection schemes; additionally, Tesla proposes an examination of and updates to current guidelines for voltage and reactive services so that these services can be provided by battery storage.
- Ahead of full market implementation, Tesla supports direct procurement of services to allow grid operators to maintain system security efficiently and timely, with procedures to encourage technology neutrality and 'pay for performance' incentives to encourage both speed and accuracy of response.

Tesla looks forward to continued engagement on these items and is highly motivated to support the Commission as it explores the detailed technical and operational requirements for enabling Ancillary Services from all technologies. As discussed in detailed comments below, Tesla believes that a complete set of market design rules supporting providing of all grid services battery storage can provide, is an essential prerequisite to achieving India's vision to integrate over 450GW of renewable energy by 2030. Additional detail relating to Tesla's position is included in the content below. To discuss any of the content, please contact me at mkhurana@tesla.com.

Sincerely,

Manuj Khurana
Senior Public Policy and Business Development Advisor

Enc: Comments

General Comments

Battery storage presents several unique values in grid-integrated settings; unlike other forms of energy storage or conventional power generation, batteries provide more flexibility as both a transmission asset (supplementing the "poles and wires" infrastructure of the electric grid) and as a generation asset (charging and discharging power back to the grid when it is needed most). In both generation and transmission applications, batteries can help maintain grid stability by turning on and off in fractions of a second, and can be sized to provide a wide range of applications, from large-scale batteries connected to the electric transmission system, to smaller scale batteries installed in the home for backup power which can be deployed in aggregate via autonomous control as virtual power plants.

For the purposes of the Draft Regulation, Tesla urges the Commission to consider refinements which recognise that battery storage can stack multiple distinct grid services and therefore provide multiple sources of market value across different timescales. Ancillary Services are one segment of grid services where battery technologies have demonstrated their ability to enhance and drive additional efficiencies in electric grid reliability, to the benefit of all participants, the grid operators, and consumers. To date, Tesla has deployed over 6GWh of batteries, a large proportion of which are effectively providing premium Ancillary Services across the globe. For example, Tesla's 100 MW battery operating since 2017 at Hornsdale Power Reserve[1] in South Australia, utilizing our Autobidder autonomous optimization software, has driven down consumer energy prices while also mitigating several grid constraints and emergency events caused by weather, transmission outages, and plant outages across the Australian grid.[2] In the same region, Tesla has also deployed its smaller residential batteries at a scale of several thousand individual assets, which operating in conjunction as a virtual power plant, have provided the equivalent level of sophistication and speed in grid balancing responsive services to stabilise the grid, as the Hornsdale facility.

The lessons learned from Tesla's global engagements with market operators on batteries make it clear that for a large, complex grid such as in India's, primary, secondary, and tertiary frequency control are "must-have tools" to ensure stability of the nation's evolving power system. Tesla applauds the Commission's undertaking to develop holistic and comprehensive framework for Ancillary Services that is fit-for-purpose for India's energy system of tomorrow – a system that will evolve to integrate new inverter-based technologies to support high penetration renewables and distributed energy resources, and support India's ambitions to integrate over 450GW of renewable energy by 2030.

[1] Since expanded to 150MW in 2020. Victoria Big Battery (300MW) will provide the same services starting Nov 2021.
[2] See Appendix for additional background.

As recognised in the Draft Regulations, a long-term, tailored market framework to support reliability and system security will necessarily rely on the capabilities of fast-response and flexible resources, including demand side response, battery storage and distributed energy resource participation. Ensuring appropriate frameworks now, offers the Indian electricity market and its stakeholders a much less volatile price discovery mechanism, and therefore more certain investment signals. This in turn allows the Commission to encourage domestic and foreign participation from technology providers to boost the formation and ultimate maturation of the ancillary markets, given the planned exit of large volumes of incumbent conventional generators which presently provide most grid system security services.

A clear price signal for alternatives such as demand response and battery storage is required today if it is expected that these technologies will form the bulk provision of this service in the years to come, and also ensure a back-stop insurance against early closure of thermal plant. It follows that different characteristics for power system operations will be required, and as CERC itself notes in the Explanatory Memorandum to the Draft Regulations, *"fast response reserves become all the more essential in view of the increasing penetration of intermittent renewable energy sources"*. Indeed many additional fast-frequency and inertia services are actively being introduced in other markets.

Based on our global experience, the overarching aim for ancillary service design should be to use co-optimised, market-based procurement where possible, and where not possible, structured procurement approaches. Market design should also try to enable new, lower-emission technologies to provide all ancillary services in addition to energy requirements and recognise that fast and flexible response is an increasingly important characteristic of a future energy system and should be valued as such. Tesla notes this may also require additional mechanisms across investment timeframes (e.g. reserve payments, flexible market contracts) to provide investor certainty.

As the Commission develops these Ancillary Services, battery storage can be considered for the full suite of services it is capable of providing. Efficient price signals for services are important and as a multi-purpose, duration-limited assets, battery storage systems need signals in operational timeframes to provide the right service when it is most needed. Additional recommended design principles for the final Regulation include:

- **Clear, consistent information and data sharing protocols** - ideally aligned with global best practice (this ensures global equipment manufacturers and operators do not have to re-design hardware and firmware for a single market and leverages existing experience based on what is most effective)

- **Complementary compensation for services** –for example,primary frequency response should count towards slower secondary frequency procurement targets to incentivize early frequency stabilization.
- **Continued efforts to collaborate with industry**, as the transition towards clean energy will require flexible frameworks and ability to quickly update technical standards, procurement volumes, and design features.

Detailed Comments on the Draft (Ancillary Services) Regulations

Payment

We note that the Draft Regulations aim to provide mechanisms for procurement "through administered as well as market-based mechanisms" **[Clause 2]**. Further clarity on how these administered mechanisms will be structured, should be released by the Commission in a supplementary issuance to these Draft Regulations, or posted for future public discussion and further comment. We believe these stepswould be very helpful for all stakeholders to assess viable commercial models ahead of the longer-term finalisation of a full suite of market design changes.

Provided the administered process supports the principles of technology neutrality in a way that enables participation of all technologies (*i.e.*, seek provision of well-defined services, not particular technology types) and clearly defines performance parameters (tightening language used in the Draft Regulations), **Tesla supports recommendations to pursue direct contracting as an interim measure.** The experience of trialling layered markets such as the enhanced frequency response procurement by National Grid in the UK[3] provides a useful example of how clear procurement guidelines can support the deployment of new technologies ahead of broader market reform. It can also be expected that this approach still allows market-based price discovery to ensure the principles of economic efficiency are maintained.

Tesla supports the introduction of 'pay for performance' elements [Clause 12(3)] that incentivise, recognise, and reward the accuracy *and* speed of response characteristics from providers of Ancillary Services. These design features not only signal opportunities for new technologies to enter the market, but also ensure value for money objectives are upheld and electricity consumers, governments and utilities obtain efficient quality and quantity of services. As noted by the India Energy Storage Alliance (IESA), *"market structures to incentivise performance ultimately saves more money at system level and improves grid reliability"*.[4] As the Commission is well aware, many ancillary market designs are now

[3] https://www.nationalgrideso.com/future-energy/innovation/projects/enhanced-frequency-control-capability-efcc
[4] https://www.energy-storage.news/news/india-prepares-to-open-up

looking to introduce fast frequency and inertia segments to address sub 1-second frequency stabilisation services.[5]

Service Specifications

The eligibility requirements outlined in the Draft Regulations are generally sensible inclusions and align with Tesla's experience complying with Ancillary Service specifications in other markets. However, **sustain requirements - 30min for Secondary services [Clause 7(1)(e)] and 60min for Tertiary [Clause 14(b)] are unnecessary and penalising for storage.** These requirements prevent batteries from bidding this reserve energy for other services and providing incremental energy value to the grid – (for comparison, there is no similar sustain requirements for Australia frequency markets). Therefore, Tesla encourages the Commission to remove these sustain requirements from the finalised regulations.

Registration

The Draft Regulations outline how service volumes will be calculated by the Nodal Agency. However, the process for registration of storage assets is unclear. In particular, it is important that the registration process contemplate **service volumes which reflect the full nameplate capacity of plant** and appropriately assign value to thefast response and accuracy of battery storage. Similarly, additional clarity on dispatch and settlement intervals would help stakeholders better understand the parameters for registration, noting that **the move to greater granularity (from 15min to 5min) is an important enabler for optimisation of fast assets [Clause 10 (12), 11(2) & 18(3)]**. Monthly bid procurement could also be more dynamic and granular – this will create more value for the grid operator to ensure services are available on interval basis and allow operators to better optimise their resources.

Network connection requirements

Tesla encourages CERC to explore progressing complementary changes to secondary or supporting technical standards and grid code obligations, so that the objectives of driving efficient and enhanced provision of Ancillary Services can commence as quickly as practicable following the finalisation of these Regulations.

For example, removing onerous and out-dated bi-directional communication requirements to better reflect the capabilities of inverter-based power electronics will facilitate interconnection and Ancillary Service participation from battery storage at all scales. To this end, it would be helpful to **clarify that storage has access to these markets at both transmission [Clause 2, 7(1), & 14] and distribution network level, and, and access these distinct grid functions either as a stand-alone asset, as a co-located asset**

[5] https://www.aemc.gov.au/rule-changes/fast-frequency-response-market-ancillary-service

paired with other generation assets (hybrid), or as a fleet of aggregated, distributed(behind-the-meter) assets. In line with our recommendations above for further public stakeholder engagement as the Commission refines the Draft Regulations, Tesla welcomes the opportunity to share our experiences deploying and operating systems across each of these unique segments, and the learnings obtained for ancillary service specification design.[6]

We also **support exemptions for storage from 'double charging' network costs when providing Ancillary Services [Clause 22].** However, this principle of exemption could apply more broadly for any storage charge or discharge event (across both energy and Ancillary Services) – recognising storage is not a typical generator or load, and in effect acts as a net benefit to the network.

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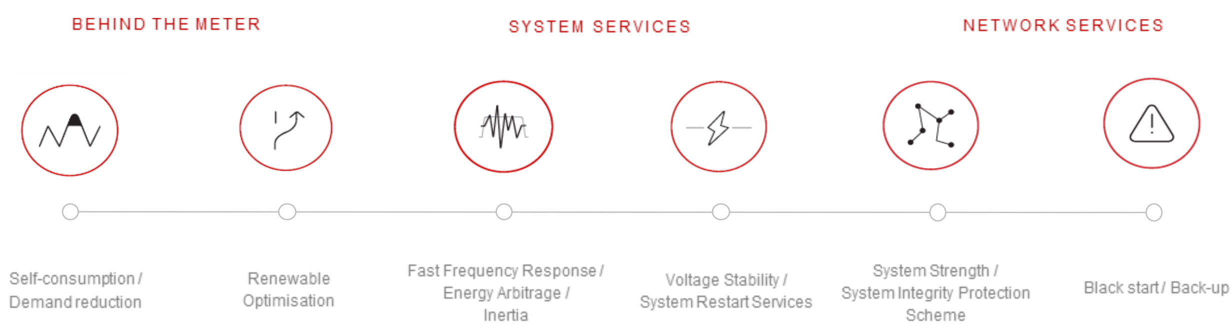
[6] *See, e.g.*, the Virtual Power Plant (VPP) knowledge sharing reports from Australia's grid operator AEMO following ongoing demonstrations in Australia which highlights the positive contribution from VPPs, available at https://aemo.com.au/en/initiatives/major-programs/nem-distributed-energy-resources-der-program/der-demonstrations/virtual-power-plant-vpp-demonstrations. .

Appendix – Essential System Services from Battery Storage

Today, battery systems with grid-forming inverters are starting to be recognised for their ability to provide the full suite of ancillary or 'essential system services', across frequency, system strength, voltage control, virtual inertia, and system re-start services. As the pace of technology innovation quickens, battery storage will be on track to provide these services at scale within the next few years, provided the right market incentives are put in place.

The benefit of batteries providing ancillary services is supported by Aurecon's Year 2 report on Hornsdale Power Reserve in South Australia, while its Year 1 report does a great job at explaining the technical capabilities.

Figure 1: Multiple applications from a single technology



In addition to on-site optimisation and premium system wide services, battery storage can also act as network infrastructure, providing voltage support, reducing line losses, offsetting the need for new lines or transformers, and providing network congestion relief ('virtual transmission').

Tesla's latest utility scale battery product, Megapack is a self-contained unit that can energise the AC bus from its DC energy (we note that other non-Tesla batteries often require additional energy sources for ancillary cooling systems).

Updating technical requirements and grid frameworks will be critical to scaling battery storage deployments and ensure they can be effectively utilised to provide energy, system and network services and optimise existing assets in a way that minimises the overall cost of the energy transition to consumers, whilst ensuring a safe, secure, and reliable system throughout.

In contrast to this multi-purpose nature of battery storage, singular-focused solutions such as synchronous condensers may only provide some categories of benefits, at much smaller scale, and with less tune-ability and precision. Whilst network and system operators have extensive experience with these traditional (and expensive) assets, it is only a matter of time until familiarity with grid-forming inverter technology grows – with several battery systems already actively demonstrating provision of system strength and virtual inertia through 2021.

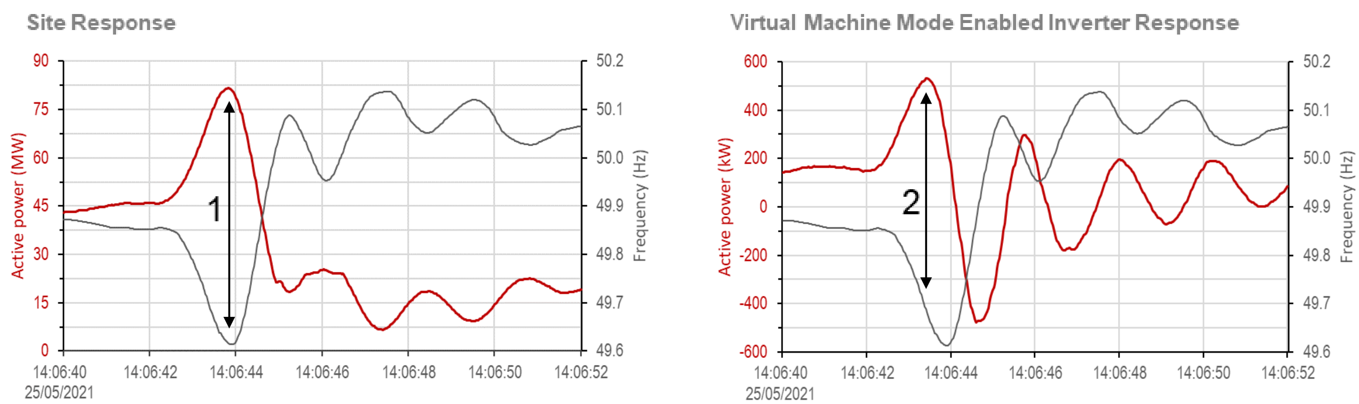
Inertia

The flexible and fast controls in a Tesla Megapack inverter can re-produce the response of a traditional rotating machine. As the inverter's inertial response is purely created by the inverter controls, not the physics of a rotating mass, the response is tune-able and can be modified based on the grid's needs (unlike traditional generators that have a fixed inertial constant based on their physical characteristics).

Tesla battery systems have a virtual machine model that can mimic the response of a traditional rotating machine to provide an inertial response. The virtual machine is a blended mode (grid following / grid-forming) that brings dispatchability of current sources with stability benefits of voltage sources.
The virtual machine model is a flexible feature that can be enabled or disabled as required. Its parameters such as inertial constant, frequency droop, and impedance are fully configurable and can be tuned to obtain the desired dynamic behaviour for the grid.

Figure 2: Hornsdale Power Reserve – Virtual Machine Mode Response during contingency

Notes: Virtual Machine Mode is enabled on 2 HPR inverters; chart shows measured response to system event on 25 May 2021; metered frequency data has been up-sampled from 200ms measurements to align with 25ms power data sampling rate.



- Active power response proportional to frequency
- Response commences once frequency departs the configured deadband
- Maximum power response when frequency reaches lowest point (nadir)

- Active power response proportional to Rate of Change of Frequency
- Response commences prior to frequency departing configured deadband
- Maximum power response when frequency is changing the fastest
- Stabilising effect to dampen overshoot of corrections by broader system

As the data shows, Virtual Machine Mode (VMM) mimics the response of a synchronous generator and provides an inertial response resisting the change in RoCoF, injecting power during the decline of frequency to help raise the nadir and providing frequency stabilisation with Primary Frequency Control recovery to the Normal Operating Frequency Band (NOFB). VMM also provides a voltage-smoothing function to resist change in the underlying voltage waveform, effectively providing a source of system strength.

Restoration and Re-synchronisation

Recent separation events in Australia provide another instructive example of the existing capabilities of battery systems to respond rapidly to provide grid support (transitioning from AGC signal to support the islanded grid), before playing a critical role in ensuring a smooth and seamless re-synchronisation with the wider network.

As noted in the grid operator's report:

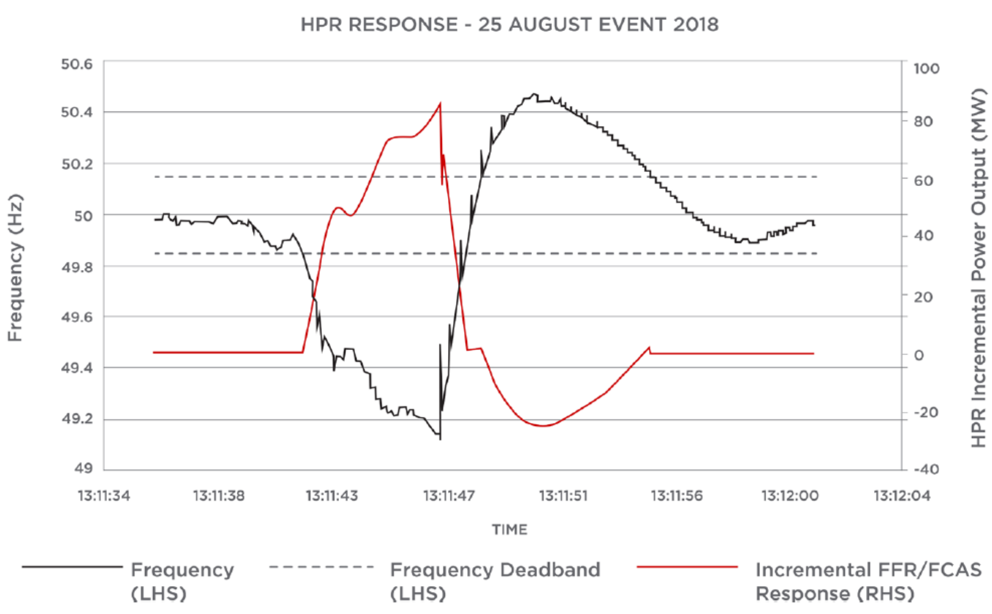
> *"The plan [for managing islanding] involved Lake Bonney, Dalrymple, and Hornsdale batteries being constrained to zero MW output but remaining at a state of charge sufficient to allow provision of raise and lower contingency frequency control ancillary services"*[7]

The role and capabilities demonstrated by battery storage in this situation could be considered analogous to system restart provision, including transitioning control to third-party generators once the islanded grid was restored.

Fast Frequency Response

Tesla's battery systems react automatically and almost instantaneously to locally measured changes in system frequency outside predetermined set points. For example, as demonstrated by Hornsdale Power Reserve (HPR), the battery's fast frequency response is well suited to supporting restoration of frequency and is of particular value in arresting a high rate of change of frequency during initial frequency disturbances. It rapidly and accurately follows the frequency and provides its required active power response for both small deviations – caused by minor contingency events or in support of the Secondary Ancillary Service, and large deviations caused by more significant contingency events.

Figure 3: Hornsdale Power Reserve Frequency Response



HPR currently provides its 'premium' fast-frequency capability through participation in Australia's existing contingency frequency markets, albeit with a much faster response than required by these markets. Recognising that batteries are already providing a form of Fast Frequency Response, the Australian

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[7] www.aemo.com.au/-/media/files/electricity/nem/market_notices_and_events/power_system_incident_reports/2020/preliminary-report-31-jan-2020.pdf?la=en

regulators have recently determined to introduce a 'faster' frequency ancillary service that will likely reward provision under 1 or 2 seconds.

Deadband and droop can also be custom defined. For example, it can flexibly configured to be more or less aggressive for system support, depending on the region, scenario or outcome being sought. This can also be dynamically changed to ensure tighter control as conditions change.

Self-start capability

For self-starting services, Tesla can activate its grid-forming mode. However, to ensure desired service outcomes can be achieved, we recommend grid requirements define an island control automatically, or through a centrally directed manual switching. The re-synchronisation with the power system can then be performed either automatically, or manually – enabling transition back to PQ mode (grid-following) with precise voltage and frequency control maintained throughout.

As noted above on Tesla's blended virtual machine mode, following suitable grid-forming services and the restoration of the grid, Megapack automatically transitions back to grid-following mode.

Premium voltage/reactive power

Similar to system re-start and restoration, Tesla Megapack has demonstrated capability to provide voltage control through precise real and reactive power provision. Local voltage levels instruct the battery what real and reactive power to inject into the system. The nominal levels for both can change (and be set) dynamically.

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