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Sebastien Henry
Australian Energy Market Commission
PO Box A2449
Sydney South NSW 1235

20 April 2017

Re: System Security Market Frameworks Review – Directions Paper (ref. code: EPR0053 – System Security Market Frameworks Review)

Dear Mr Henry,

Tesla Motors Australia Pty Ltd (Tesla) welcomes the opportunity to provide a submission to the Australian Energy Market Commission (AEMC) System Security Market Frameworks Review Directions Paper (the Directions Paper).

1. Introduction

Tesla views the proposed packages as a positive step towards creating a market that supports the full range of benefits that can be provided by new technologies such as battery energy storage systems.

The System Security Framework Review work is an important transitionary step recognising that the Australian national electricity market (NEM) has changed significantly over the last decade, and that new mechanisms need to be implemented as we transition further away from complete reliance on synchronous generation.

Battery energy storage plays an important role in this transition. Energy storage can provide almost any grid service required. Storage can act like generation, provide fast-responding ancillary services and shift energy production from off-peak times to on peak times, reducing the need for new peaking generation capacity. Storage can act as transmission and distribution infrastructure, providing voltage support, reducing line losses, offsetting the need for new lines or transformers, and providing transmission and distribution congestion relief.

The major impeding factor impacting on greater uptake of battery energy storage is that few of these services are currently monetised through the NEM framework.

Tesla recognises that the provision of frequency services and participation in Frequency Control Ancillary Services (FCAS) markets has to date been dominated by synchronous generation. As a result, and noting that not all battery energy storage system applications are monetised, non-synchronous generators have had less of an economic incentive to provide system security services.

As such as Tesla welcomes the development of new procurement approaches and new markets which are going to provide greater access to frequency and system security revenue streams for battery energy storage systems. We particularly welcome the fast frequency response (FFR) contractual provisions included in the immediate package, which provide increased investment certainty for first-mover adopters of battery energy storage systems to deliver both FFR and synthetic inertia.

The following submission provides an overview of the Tesla response to the relevant sections of the Directions Paper. Our key points are summarised as:

- It is critical for all mechanisms introduced to remain technology agnostic, with AEMO setting the technical requirements for both the provision of inertia and FFR. Tesla supports the idea of substitutability between two technologies, particularly as technical capabilities continue to be proven and evolve.
- Australian Energy Market Operator (AEMO) capability testing and drafting of FFR technical guidance should begin as soon as the draft rules are published. This will provide technology providers sufficient time to adjust systems and adapt interfaces as required.
- Tesla supports a procurement approach that creates the greatest net benefit for the electricity market for both inertia and FFR.
- The transitionary period between the immediate package and subsequent package needs to be managed in a way that provides sufficient revenue certainty for investors. A minimum contractual duration between Transmission Network Service Providers (TNSPs) and third party providers of FFR should be set to ensure this certainty.

A more detailed overview of Tesla's view in respect of the individual mechanisms and proposed procurement approach is outlined below.

2. Key Considerations for evaluating the mechanisms

Tesla is broadly supportive of each of the proposed three transitionary steps included in the immediate package, particularly the following:

- TNSP procurement of FFR through contracts with third party FFR providers.
- Obligations on new non-synchronous generators to have capability to provide or have contracted access to FFR services.

We are also supportive of the two additional proposed mechanisms within the subsequent package, both the TNSP incentive framework and the transition to a market sourcing approach for FFR. Additional detail on our positioning in respect of the proposed mechanisms themselves, and the proposed procurement approach is provided below.

Technology agnostic approach

Tesla believes that it is critical to take a technology agnostic approach in all relevant rules and technical guidance related to both inertial requirements and FFR.

The Directions Paper considers the substitutability of traditional inertia technology (synchronous generation) with FFR technology and acknowledges there is a degree of overlap and substitutability, with the AEMC noting that an FFR service can be used to meet the required operating inertia levels.

The Directions Paper also notes that FFR technologies involve a time delay to measure the initial change of frequency, which results in a level of inertia that cannot be provided by FFR technologies.

In addition it points to international experience that suggests that synthetic inertia from non-synchronous generators cannot provide a direct replacement for traditional synchronous inertia[1]. However, it notes that in the future it might become possible to use inverter-connected devices to constantly and instantaneously maintain frequency.

Tesla strongly encourages the AEMC and AEMO to adopt a technology agnostic approach for determining the types of systems that can provide both inertia capacity and FFR, with providers simply needing to demonstrate that they can meet the technical requirements as established by AEMO. This approach is ultimately more supportive of the substitutability of FFR and inertial response technologies and any future replacement of traditional inertia with synthetic inertia.

Tesla energy storage systems' provide a flexible and fast controllability, with a switching frequency approximately 10 times faster than traditional inverters enables us to provide inertial response - or synthetic inertia that is consistent with the system security provided by traditional synchronous inertia. Tesla energy storage systems can mimic inertial response of traditional generators and let grid operators achieve the inertial response behaviour that supports reliable grid operation.

Tesla's energy storage system's synthetic inertial response can be adaptive and modified based on the grid conditions by the grid operators in real time, unlike traditional generators that are restricted by their physical characteristics in providing a constant inertial response behaviour. Tesla energy storage systems' capability to provide fast, well-shaped, and coordinated synthetic inertia improves power systems frequency stability. This approach is particularly well suited to electricity grids with higher renewable energy penetration.

Based on this, Tesla would like to see an inertia market that is open to accepting synthetic inertia where technical capabilities meet AEMO defined requirements. Tesla recommends that no explicit reference to any technology type is given in the AEMC draft rules or any AEMO technical guidance documents developed. The AEMC or AEMO requirements should not act as a barrier to deployment of the rapidly evolving capabilities of technologies such as battery storage.

A full overview of Tesla's frequency control services is included at Attachment A.

Prioritisation of testing and capability proving by AEMO

Tesla notes that there are a number of references throughout the Directions Paper in respect of FFR technologies being 'immature' or 'fledgling'. This is true in respect of the interaction of FFR technologies and the Australian electricity market.

We acknowledge that AEMO and ARENA are currently trialling proof of concept projects, however we suggest that AEMO gives immediate prioritisation to testing of FFR capabilities and consulting on technical requirements as soon as the AEMC releases the draft rules, following this Directions Paper.

There is a risk that the transitionary approach suggested by the immediate package will be viewed as a soft-start for trialling FFR technologies in Australia – rather than a necessary step in providing first-movers with appropriate compensation for grid services and system security provided.

This may result in shorter FFR contractual durations as TNSPs will view FFR technologies as emerging and ill-defined.

Tesla also believes that it is important to acknowledge that while the delivery of FFR services from battery energy storage technology is new, there are a number of existing commercial scale battery

[1] Directions Paper, Pg. 6

installations across Australia. As such, further testing and additional proof of concept projects can commence immediately following the introduction of the draft rules.

Tesla would like to see FFR Technical Guidance released as soon as is feasibly possible to avoid future concerns that the technology is emerging and ill-defined.

3. Mechanisms for procurement and proposed approach for procuring inertia and FFR

Tesla supports the TNSP FFR procurement approach proposed in the Directions Paper – specifically that TNSPs contract with third party FFR providers with AEMO approval. Our understanding is that this approach may be inherently linked to the requirement on new non-synchronous generators to install FFR capacity, who may use the capacity themselves or contract it out to TNSPs.

We support an approach to procurement that provides the greatest net benefit to the Australian national electricity market (NEM), with clear and transparent advice on the procurement approach and technical requirements.

As noted in the Directions Paper energy storage systems provide a number of grid services beyond FFR- as a result, co-locating at a site where it can provide additional services provides the greatest net benefit to the NEM and market participants.

In respect of the detailed outline of the procurement approach specified in the Direction Paper – Tesla considers the following:

- As noted above, Tesla supports a TNSP procurement approach that is technology agnostic. This will provide TNSPs greater flexibility when it comes to substitutability of the two services. Note as well that the TNSP procurement approach assumes that a market participant is willing and able to bear the upside risk – this is reliant on revenue certainty (see below for further detail).
- To support a transparent and consistent approach to TNSP participation, AEMO should provide clear and transparent guidance on the levels of FFR and inertial requirements with the implications clearly outlines in any procurement and contractual guidance developed.
- We support obligations on new generators to have installed FFR capabilities. From a location perspective it makes sense for generators to be able to couple this FFR capability with access to additional revenue streams – wholesale energy market participation and FCAS market participation. The AEMC should note that in a number of NEM jurisdictions, these traditional applications will not be sufficient to make the inclusion of FFR technologies – such as battery energy storage – economic. From a generator perspective contract certainty and extended contract durations will improve investment consideration. Without contract certainty there is a risk that new non-synchronous generation becomes uneconomic.

A more detailed overview in respect of these points is included below.

Technical guidance needs to be transparent and consistent

Broad consistency across the TNSP procurement process for both inertia and FFR is required – including both technical requirements and basis for payment

As noted above, Tesla recommends an early prioritisation by AEMO on capability testing. Following this, FFR technical requirements should be clearly and transparently outlined in technical guidance documents to ensure that the TNSP contracting approach is broadly consistent.

Note that this may require some consideration of whether the RIT-T procurement is the appropriate mechanism for procurement of inertia. Specifically this will involve a consideration of whether the procurement approach is capable of considering the substitutability of inertia requirements with FFR, or whether it inherently favours TNSP construction of synchronous generation – as suggested in the Directions Paper.

Investment certainty for first movers is needed

We note that the AEMC does not propose to put a duration limit on the contracts between TNSPs and third party providers of FFR, noting also that transition to the market with the introduction of the subsequent package will not overwrite contracts already in place. Tesla recommends that minimum contractual duration for FFR services would significantly advance first mover projects in the Australian market. This would be further enhanced by transparency on the established basis of payment

A low or ill-defined contract duration provides lower upside certainty for the technology owners who will be looking for investment certainty as early adopters of FFR providing technologies. This would be linked to the condition that the technology is capable of meeting all of the technical requirements established in any overarching FFR guidance.

The Directions Paper notes that technologies that provide FFR services are also likely to be providing these services as a by-product of other services. Energy storage, as a provider of FFR, can certainly participate in other markets including FCAS or wholesale energy. However the revenue available from these markets differs dramatically on a state by state basis.

It's also important to note that improved frequency control resulting from a successful implementation of this package will also have the likely impact of lowering FCAS revenue streams.

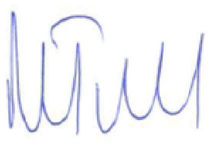
As FFR provision is a new service in Australia, first mover technology revenue certainty is very important in ensuring a successful roll-out of the three mechanisms of the immediate package.

4. Conclusions

Tesla is very supportive of the proposed mechanisms driving the uptake of FFR technologies. We are excited to see a procurement approach progressed that is transparent, technology agnostic and guides investment certainty.

We look forward to working with both the AEMC and AEMO as these enabling rule changes are implemented and technical guidance is developed.

Kind regards



Mark Twidell

APAC Director – Energy Products

Tesla Energy Storage Systems Improve Grid Frequency Response

Frequency Response in Power Systems

Power systems response to frequency deviations caused by a sudden mismatch between their generation and load is derived from three response types: Inertial Response, Primary Frequency Response, and Secondary Frequency Response. Tesla energy storage systems can improve the frequency stability of a grid by providing all three forms of frequency response.

Inertial Response

Immediate response of rotating resources in power systems to disturbances that cause grid frequency fluctuations is called "Inertial Response". The inertial response of a power system limits its rate of change of frequency after disturbances, thus impacting the maximum frequency deviation that the system reaches before other frequency control mechanisms in the grid react. Grids with lower inertia experience faster frequency dynamics, larger frequency deviations, and usually lower frequency stability margins. Large frequency deviations caused by disturbances in a grid might cause operation of under frequency load shedding (UFLS) relays, or trip renewable resources with tight frequency ride-through settings, and in extreme cases cause system-wide outages.

In conventional power grids, rotational inertia of synchronous generators' turbine mass provide inertial response. Inverter-interfaced renewable resources such as wind and solar PV do not usually provide inertial response, thus reducing the grid's overall inertial response. Consequently, with the increasing penetrations of renewables in power grids, providing fast frequency response to counterbalance the low inertia has become of higher importance. Tesla energy storage systems' flexible and fast controllability, with a switching frequency approximately 10 times faster than competitor inverters enables us to provide inertial response also known as "Synthetic Inertia" in modern power grids. Tesla energy storage systems can mimic inertial response of traditional generators and let grid operators achieve the inertial response behavior that supports reliable grid operation.

Another important implication of high renewable penetrations in power grids is that rotational inertia of a grid varies significantly over time due to variability of renewables outputs and thus varying the dispatch and availability of grid resources with inertial response capability. This causes uncertainty, unpredictability, and inconsistency of the grid's frequency response over time (seconds, hours, days, and seasons). Tesla's energy storage system's synthetic inertial response can be adaptive and modified based on the grid conditions by the grid operators in real time, unlike traditional generators that are restricted by their physical characteristics in providing a constant inertial response behavior. Tesla energy storage systems' capability to provide fast, well-shaped, and coordinated synthetic inertia improves power systems frequency stability.

Primary Frequency Response

Primary frequency response is the control mechanism that is typically activated autonomously a few seconds after a frequency deviation event and is typically sustained for up to 30 seconds. The primary frequency control is designed to keep grid frequency within acceptable limits after large disturbances on the grid. The primary frequency response provided by all the resources on the grid determines its maximum frequency deviation after a disturbance, and grid planners and operators work to maintain this point above the UFLS relays settings to avoid system outages.

Primary frequency response has traditionally been provided by governor control of generators. Governors automatically respond to a change in system frequency by changing of the power generation unit's output power. Governor response is controlled by a droop setting, typically in the range of 2%-5%. A droop setting of 5% means that 5% change in grid frequency results in 100% change in the generation unit's output power.

Tesla energy storage system can provide primary frequency response in the grids. This response can mimic the traditional generators' governor response or be optimized to achieve the best frequency behavior based on the grid characteristics.

Secondary Frequency Response

Secondary frequency response is the control mechanism that is activated to bring the grid frequency back to its nominal value after the primary frequency response settles to steady state and contains the frequency deviations. Secondary frequency response is typically activated within 30 seconds after a disturbance and can be sustained for up to 30 minutes. Usually the secondary frequency control is dispatched from a central location by the grid operators via SCADA systems as part of the grids' frequency regulation or automatic generation control (AGC) systems.

Tesla's energy storage system is capable of receiving AGC signals from grid operators and providing the commanded secondary frequency response to maintain the grid frequency. The application of fast acting power electronic devices and control mechanisms in Tesla's energy storage systems enables faster and more accurate response to AGC and frequency regulation signals compared to traditional generators, which have slower control systems and limited ramp rate capabilities due to their physical characteristics. Also, conventional generator's response is generally limited to a percentage of their nameplate values, whereas Tesla energy storage systems can provide these services in both charge and discharge conditions up to their rated values if required.

Typical Grid Frequency Response

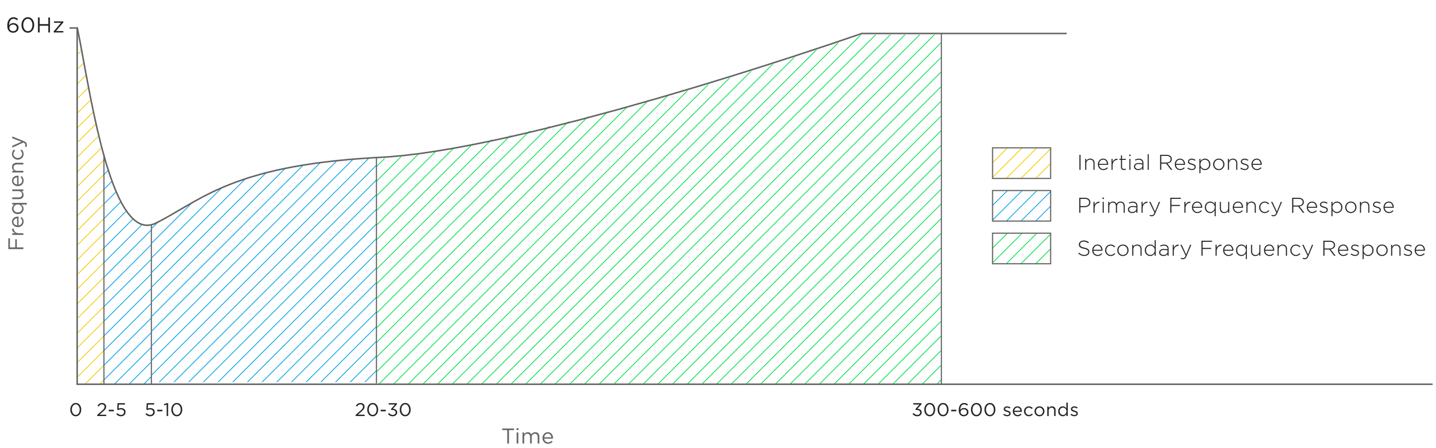


Figure 1 shows the typical frequency response of a grid after a loss of generation event in the system.

Right after the loss of generation, the grid frequency starts declining and the inertial response of other generators on the grid limits the rate of frequency decline. The primary frequency control mechanisms (e.g. generators' governors) become active when the frequency drops outside of a pre-set frequency band. The grid's primary frequency response starts to increase the generation in the grid and the grid frequency decline starts to recover, thus restricting the minimum grid frequency a few seconds after its activation. Typically, 30 to 60 seconds after the governor response is initiated, the grid frequency recovers to a new value lower than the nominal grid frequency. The secondary frequency response instructed by the grid operator at this time attempts to bring the grid frequency back to its nominal value. For a grid to remain stable, the grid frequency response should be within the grid's UFLS and frequency ride-through settings to avoid multiple generation trips and/or rolling blackouts.

Tesla Inverter Control Modes

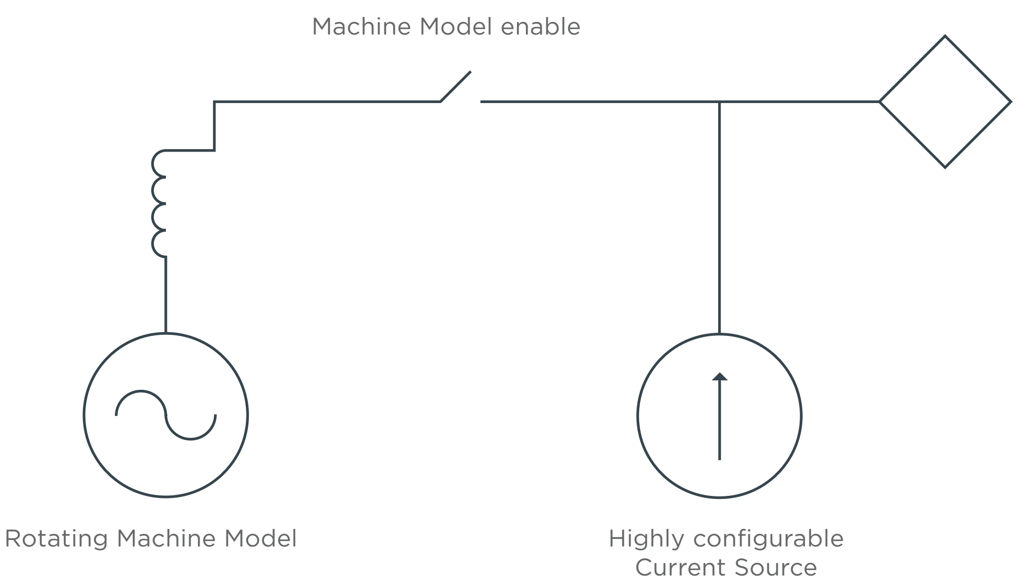


Figure 2. Grid frequency response under different renewable penetrations

The Tesla Inverter has a versatile control architecture and can operate in three distinct modes: Current Source Mode, Virtual Machine Mode, and Blended Mode. In the Current Source Mode, the inverter provides ultra-fast response to commands (100% current change in less than 4ms), a full suite of smart inverter functions, and fully configurable settings. In the Virtual Machine Mode, the inverter supports emulated inertia (synthetic inertia), grid forming functionalities, voltage/frequency stabilization of the grid, and harmonics damping. In the Blended Mode, the inverter provides both the Current Source Mode and Virtual Machine Mode such that the machine model is configured to act similar to a "synchronous condenser" alongside the current source model. The Virtual Machine model parameters such as inertial constant, frequency droop, and impedance are configurable and can be tuned to obtain desired dynamic behavior of the grid. The inverter can seamlessly transition between control modes if required by the grid operator.

Utilizing its unique inverter control architecture, Tesla energy storage systems can provide inertial response, primary frequency response, and secondary frequency response to help maintain the stability of power grids.