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Dr Alex Wonhas
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Re: Tesla Response to Draft ISP

Dear Alex,

Tesla Motors Australia, Pty Ltd (Tesla) welcomes the opportunity to provide AEMO with feedback on its Draft 2020 Integrated System Plan (ISP), building on our recent submission to the Planning and Forecasting consultation.

Tesla commends AEMO's work in developing, modelling and refining the ISP, working closely with industry and government on what has been an influential document since first publication in 2018. The finalised 2020 ISP will continue to drive Australia's energy market discussions forward, and will undoubtedly be used as a credible reference for energy policy decision making in the years to come.

Tesla's submission focusses on storage, recognising it will play a critical role in a highly renewables grid, and the storage mix in Australia will likely include a portfolio of long-duration pumped-hydro energy storage (PHES), grid-scale battery storage (BESS), and distributed energy resources (DER) operating as virtual power plants (VPP). Ultimately, this mix will be driven by investment and market factors, technical need, policy drivers and deployment flexibility, and the commercial value of each new project will need to be assessed against alternative technologies and applications.

A key concern is the ISP's proposed storage mix, in particular noting the lack of grid-scale battery storage included in the draft 2020 modelling outcomes – a clear disconnect from the consensus view that grid-scale BESS has a critical role to play supporting the transition to an efficient, secure and low-emission future NEM.[1]

We note this is likely to be driven by a combination of input assumptions and modelling methodology. Therefore, ahead of the finalised 2020 ISP, Tesla recommends:

- **Updating input assumptions for storage** – Tesla refers to its Planning and Forecasting submission[2] that highlights the divergence between AEMO's input assumptions and what is being observed in the market (e.g. battery capital and O&M costs, duration, round-trip efficiency, state of charge, build lead times, and asset life). Tesla supports AEMO's transparency and commitment to continually update assumptions around battery costs and technical properties and would be happy

[1] see Aurora analysis: http://www.auroraer.com/insight/storage_economics_in_the_nem/; Bloomberg NEF: https://about.bnef.com/blog/australia-shows-regulated-utilities-can-storage/; PWC: www.pwc.com.au/power-utilities/future-of-energy/future-of-energy.pdf; ARENA: https://arena.gov.au/renewable-energy/battery-storage/; CSIRO: www.csiro.au/en/Research/EF/Areas/Grids-and-storage/Energy-storage; ACOLA: https://acola.org/wp-content/uploads/2018/08/role-energy-storage-future-australia.pdf; Finkel Review: www.energy.gov.au/sites/default/files/independent-review-future-nem-blueprint-for-the-future-2017.pdf; ESB post 2025 work: http://www.coagenergycouncil.gov.au/; AEMC: www.aemc.gov.au/news-centre/media-releases/coordination-generation-and-transmission-investment-review-update; and AEMO's own commentary: https://aemo.com.au/news/battery-storage; and EGES rule change; and REIS study

[2] www.aemo.com.au/consultations/current-and-closed-consultations/2020-planning-and-forecasting-consultation-on-scenarios-inputs-and-assumptions

to work with AEMO and relevant consultancies to support refinement of these assumptions.

- **Ensuring technology neutrality** - Tesla recommends the ISP returns to a technology neutral approach that reflects storage characteristics rather than technology type. New storage built will then be driven purely by commercial factors, rather than potentially influenced by a pre-determined technology outcome. Similarly, Tesla notes the additional analysis and consultant reports focused on DER uptake and supports AEMO's approach on aggregated batteries and the inclusion of VPPs as a source of general market supply akin to grid-scale storage, but this should not substitute for the entire role of grid-scale battery storage deployment across the NEM.

- **Enhancing modelling to reflect value potential** – AEMO's modelling should incorporate the additional capabilities and flexibilities beyond energy generation provided by both stand-alone battery storage (e.g. ancillary services, inertia contributions and system security benefits) as well as hybrid battery assets when paired with renewables (e.g. reduced curtailment, improved marginal loss factors, reduced causer pays liabilities). This will more accurately reflect the role and value of battery storage and better map to actual and expected market behaviour relative to other generation plant, without relying on sensitive forecast capital cost comparisons based on energy related costs ($/kW or $/kWh) - which should be used with caution for informing investment decisions.

- **Integrating upfront analysis for non-network solutions –** We note AEMO's reference to storage as a non-network alternative from a generation investment perspective, however including upfront analysis and commentary on the ability for networks to own, operate or procure services from storage assets would more broadly capture the benefits and services that can be (and are already) provided.

- **Expanding the breadth of scenario analysis –** AEMO should consider expanding its decision-making criteria for select scenarios so that a wider spectrum of future states can be modelled – e.g. including broader policy initiatives, recognising proposed storage deployments, and capturing the benefits of flexibility and optionality of various assets.

More detail on each of these items is included in the submission below. Tesla looks forward to continued engagement and actively participating in ongoing discussions to support AEMO in the finalisation of the 2020 ISP. For further information on any of the points raised please contact Dev Tayal (atayal@tesla.com) with any questions.

Kind regards

Emma Fagan

Head of Energy Policy and Regulation

Technology neutrality

The draft 2020 ISP outcomes highlight a distinct lack of grid-scale battery storage, with reference to its potential as a future technology only "*if economically viable*"[3] and not modelling any growth in grid-scale BESS under any scenario or state. As noted above, this is inconsistent with observed market outcomes, the development pipeline of grid-scale BESS projects currently announced and proposed, and is significantly divergent from modelling conducted by other market analysts – which all show a clear growth trajectory for all scales of BESS and PHES.

A key driver of this outcome is the ISP's modelling approach, which centers on duration capacity requirements (optimising for depth of storage but ignoring value potential), with forecast storage capacities found to be largely 6-hour PHES (with over 6GW built in the central optimal development pathway scenario), coupled with some build out of smaller behind the meter BESS. However, BESS is fully scalable from under 1 hour up to 8 hours in duration[4] and potentially longer depending on the use-case. The ISP also disadvantages BESS by modelling pricing based on 25MW systems (at 2- or 4-hour duration), when significant scale efficiencies would be seen for 100MW or 1GW projects – similar to PHES developments.

Longer duration requirements should not be restrictive for different technology types. BESS are modular and complementary, such that two independent 2-hour BESS may be deployed and provide up to 4 hours of duration, or two 4-hour BESS are able to provide up to 8 hours of depth for intraday energy shifting etc – in much the same way that behind the meter BESS can be aggregated and considered as a fleet when part of a VPP. AEMO must recognise that even if this deployment approach does not satisfy a least-cost system wide optimisation pathway, it is still a likely outcome based on project by project investment decision factors that will be considering market returns, the ability to use BESS assets as a hedge (e.g. for MLF or causer pays reductions), or be influenced by other direct policy interventions.

Another example of the Draft ISP distinguishing between technology over role is where only PHES is mentioned as a non-network alternative at grid-scale: "*the modelling determines that building 300 MW of pumped hydro energy storage would be necessary instead to help firm VRE and avoid load shedding*", when in reality it is grid-scale BESS being included as comparison options as part of current RIT-T processes[5].

Given grid-scale BESS assets have already demonstrated their competitiveness against other assets that are being substituted in the ISP modelling, Tesla recommends AEMO re-open its inputs and scenario assumptions for sensitivity testing. In addition, AEMO should be agnostic on storage technologies and instead present storage outcomes based on proposed roles (e.g. characteristics rather than technology types) to ensure technology neutrality – letting the market decide based on real-world value potential. AEMO should define storage as a single category (and not split out batteries from pumped-hydro at the grid scale). This will ensure the market drives suitable investment decisions without prejudice from ISP forecasts.

Highlighting a preference for particular storage technologies over others could undermine the credibility of the broader ISP and severely damage the business case for battery storage in the NEM. Noting the standing of AEMO (and the ISP document in particular) for underpinning energy policy decisions, our concern is that this may influence government and developers in selecting particular technologies due to the perception they are lowest cost or provide the greatest value.

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[3] See Appendices: aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/ISP/2019/Draft-2020-ISP-Appendices.pdf: pg 65

[4] www.utilitydive.com/news/Tesla-national-grid-battery-energy-storage-8hour-long-duration-diesel-generation-system-nantucket/564428/

[5] TransGrid NSW-QLD PADR: www.transgrid.com.au/what-we-do/projects/currentprojects/ExpandingNSWQLDTransmissionTransferCapacity/

ISP Modelling Methodology - Incorporating the full value potential of assets

The draft 2020 ISP models how various generation technologies can be integrated to replace retiring coal and gas generators, including storage. To determine the mix of assets, we note AEMO's resource-adequacy approach, which for storage may include the role of: providing peak demand support; intraday energy shifting; interday or seasonal shifting; and firming support and system security benefits. Based on the ISP outcomes promoting the role of long-duration (6 & 12 hour) PHES as the least cost development solution for the NEM and with minimal build-out of other storage technologies, it appears the intra/interday energy shifting role is modelled as having greatest influence.

Whilst instructive from a system operations perspective, the 2020 ISP would provide much greater value if it mapped to the commercial drivers and investment signals that industry and government are looking to navigate for actioning new project deployments. This would not necessarily need to be tied to existing market arrangements, still allowing for fluidity in future market and policy settings. However, some value would need to be attributed to ancillary services, network services, and other system security benefits broader than simply longer-duration energy shifting. Without these additional value streams, the value of BESS are significantly understated and do not accurately represent the reality of investment decisions.

Commercial assessments should also consider storage as a 'firming asset' with renewable generation (i.e. solar/wind and storage). This provides a more accurate cost/benefit to replacing retiring thermal plant, rather than simply viewing storage as a form of stand-alone peaking generation.

Battery storage has already demonstrated its ability to provide a broad range of services – both when co-located with renewables, and as a stand-alone, fast-response, flexible asset. When paired with renewable assets, battery storage can provide 'firming' of the renewable generation output and as such, by increasing flexibility and optimising connection agreements, storage will increase the amount of renewable energy that can be exported into the network and minimise the amount being curtailed. For new projects, this means the direct benefit of providing a higher return in revenue from the renewable generator, as well as several secondary benefits such as the ability to sell the 'firmed renewable' energy in blocks back to the market, and the ability to mitigate dispatch imbalances and associated charges (i.e. causer pays factors - regulation contribution charges that apply when dispatch limits are exceeded). AEMO's current approach to ISP modelling appears to neglect (or at least downplay) the contribution of these values, despite increasing interest in exploring market mechanisms that will recognise them in practice.

AEMO must also consider the additional capabilities and flexibilities provided by battery storage assets, such as ancillary service and system security benefits. For storage, market participation is fundamentally an opportunity cost assessment – using dispatch models and forecasting software to optimise when, in what markets, and how much to bid the limited energy capacity that is available in order to maximise returns. This is where fast-response battery storage allows for greater flexibility in market bidding strategies across both energy and ancillary service markets to maximise project revenues ('revenue stacking'). Whilst strategic bidding and commercial drivers may not be explicitly captured in AEMO's modelling, these additional revenue opportunities can at least provide an indication of the flexibility of the role battery storage can provide in the fully co-optimised NEM.

More specifically, to ensure a credible model of future generation capacity, AEMO must find a way to incorporate the full range of potential ancillary service benefits of battery storage, beyond solely energy generation. For example, an alternative approach could include reducing the upfront capital cost of battery storage deployments by a 'factor' to reflect that some portion of the asset will paid for and used by network utilities (for network services), whilst the remaining capacity can still be market facing and provide energy and frequency services[6].

[6] See Baringa REZ report: https://arena.gov.au/assets/2020/01/development-of-renewable-energy-zones-in-the-nem.pdf

- As acknowledged by both AEMO[7] and Aurecon[8] independent assessments, battery storage can support stable grid frequency through the provision of a 'premium' frequency control ancillary service (FCAS) – offering flexible, more accurate and faster performance in following control signals to continually counteract frequency deviations during normal operating conditions for regulation FCAS, and incredibly rapid response for both credible and non-credible contingency events.
- As demonstrated recently, services from the fleet of grid-scale batteries in (islanded) SA have been used by AEMO to support grid stability through storms, bushfires and unexpected thermal outages (see public commentary[9]). It is interesting to note AEMO managed to re-stabilise the SA grid largely through the response of wind and solar farms, and three grid-scale battery storage assets – with no coal or hydro assets. This is yet another example of the value that accurate and responsive inverter-based technology provides, accompanied by optimisation software allowing for direct, flexible and immediate control.
- For future developments, it is expected that the value of the firming and system security services will only increase as more thermal generators retire and the penetration of variable renewable energy (VRE) increases. Market changes will be made to incentivise and reward all fast acting and flexible frequency, voltage and inertial responses that battery storage can offer. Over time, these non-energy services should increase their proportion of the value stack, particularly as non-traditional network support services and grid infrastructure deferrals are able to be monetised, and as regulatory reforms unlock more appropriate markets to value the services being provided.
- It is also unclear whether inertia contributions are being captured. Ancillary services should include the ability for battery storage to provide 'virtual inertia' – as currently being demonstrated to AEMO, particularly as the ISP input assumptions ultimately support a forward-looking forecast of the NEM.

Tesla is keen to support AEMO to conduct a deeper dive into the role that battery storage will play in the NEM – e.g. cost analysis, market benefits and system services that fast-response storage is already providing, along with forecast developments. This will also strengthen the link between the ISP and other market reform work already underway (e.g. NEM market design options, Renewable Integration Study, and frequency control reviews).

Market revenue sufficiency

A broader scope of modelling methodology will be increasingly important as market reforms progress to reward faster and more accurate services from BESS (e.g. the design of primary frequency incentives being developed by AEMC following AEMO's rule change proposal; or 5-min settlement starting in 2021). This will also be increasingly recognised and valued by the market as AEMO's own systems evolve to keep pace with the technical capabilities of increasingly flexible and fast-response assets.

From a revenue sufficiency basis, for daily (high frequency) market participation – fast response batteries can stack multiple services and optimise dispatch. For example, Hornsdale Power Reserve's 140ms response time and 90% round trip efficiency increase revenue by enabling participation in more markets (e.g. FCAS) with lower charging costs.

[7] https://www.aemo.com.au/-/media/Files/Media_Centre/2018/Initial-operation-of-the-Hornsdale-Power-Reserve.pdf
[8] AURECON, 2018: www.aurecongroup.com/markets/energy/hornsdale-power-reserve-impact-study
[9] https://reneweconomy.com.au/wind-and-batteries-saved-the-day-when-storm-cut-south-australia-adrift-22060/; https://reneweconomy.com.au/aemo-takes-control-of-s-a-big-batteries-to-help-manage-isolated-grid-77344/

Modelling Non-network solutions

The Draft ISP does consider non-network alternatives, however only PHES is mentioned. In practice, we are already seeing RIT-T assessment of grid-scale battery storage as non-network alternatives. For example, the recent NSW-QLD PADR[10] for upgrading QNI transfer capacity included two credible options of a virtual transmission line comprising battery systems (no pumped hydro was included). The top-ranked battery option had the greatest estimated gross benefit of all options including proposed network upgrades but was ultimately not selected based on other factors including cost allocations, commercial models and government funding commitments.

In general, we recommend AEMO's ISP process acknowledges upfront the opportunity for modular non-network solutions as an outright alternative, or complement to longer-term network upgrades – noting the lower capital costs than network solutions, much faster deployment timeframes (up to 12 months instead of 8 years), and flexibility in location.

Modelling of non-network solutions should also include a staging of deployment – driving economic benefit by deferring capital requirements until market outcomes are better understood, or providing flexibility to scale-up/down the network capacity depending on interdependencies with other network or generation investments occurring over the period (as well as the potential for any government policy announcements).

This approach could also explore the advantages provided from early deployment of a 'modest' non-network solution coupled with incremental network investment. Benefits from any immediate upgrades could be expected to be realised immediately - through avoided fuel costs, increased generator efficiency between states (e.g. for priority interconnector projects), limiting congestion, mitigating the risk from early coal plant retirement, as well as other short-term risk mitigations should any unexpected outages or system security events occur in the next 2 to 3 years.

Whilst still an emerging application for network companies in Australia, the concept of virtual transmission has already proven valuable in other jurisdictions (e.g. see 6MW / 48 MWh battery system in Nantucket Island, Massachusetts[11]) and given the demonstrated gross benefit advantages and scale of the build, warrants more detailed analysis and commentary within the ISP.

We note AEMO's intent to keep the ISP as a least-cost expansion plan and to avoid endorsing particular market design features. However, including some high-level guidance on the role and potential placement of storage (e.g. to act as 'virtual transmission') would still be highly instructive for network utilities and the market. Given the work being undertaken to create an actionable system wide plan, guidance provided by the 2020 ISP will be critical in supporting all future assessments by transmission networks and as noted above, should focus on storage characteristics rather than pre-determining the viability of specific technology types.

[10] https://www.transgrid.com.au/what-we-do/projects/current-projects/ExpandingNSWQLDTransmissionTransferCapacity

[11] www.utilitydive.com/news/Tesla-national-grid-battery-energy-storage-8hour-long-duration-diesel-generation-system-nantucket/564428/

Scenario and Sensitivity Analysis

Tesla recognises the complexity of including policy assumptions when there has typically been a two-way flow of information and the ISP has equally been used as a reference to inform policy decision making. As a starting point, we understand AEMO has attempted to distinguish between climate change policy to be included as an input (e.g. Renewable Energy Targets, emissions reductions etc), and energy policy more broadly, which is taken case by case (e.g. transmission strategies, renewable and storage funds / auctions etc). This approach may be able to directionally capture the build-out of key infrastructure across the NEM, but is prone to miss the shorter term factors that are driving particular network and generation assets being deployed on a state by state basis, often in reaction to immediate system security or reliability events.

An alternative methodology approach for the ISP is for AEMO to consider expanding its decision-making criteria (e.g. for a selection of scenarios) so that wider policy inclusions and the flexibility of storage deployments can be more appropriately included and explored:

- **Government policy initiatives** – we note AEMO has allowed for degrees of freedom when including various government funding and policy announcements. Our recommendation is to include a wider (i.e. less conservative) range of energy policy mechanisms in some scenarios, even if they have not been legislated yet or policy design is undefined, as these policies will still have significant impact on new build capacity in the new term – particularly for storage.

- **Battery storage deployments** - Tesla estimates that 240MW of grid-scale battery storage has already been commissioned in the NEM (with a strong pipeline of further MWs currently under construction, with financing decisions made, or publicly announced projects at varying levels of planning stages). In contrast, AEMO's Draft ISP models 215MW of grid-scale battery storage declining to 110MW (as assets reach end of life and are not replaced with future projects) with no growth pipeline for all scenarios. Noting that satisfying AEMO's commitment criteria before being included as an 'operational asset' is less suited for battery storage than traditional thermal plant, AEMO could consider modelling some scenarios with alternative commitment thresholds for battery projects.

- **Deployment flexibility** - High impact / low probability events are notoriously difficult to forecast and model, however AEMO could consider including climate change risk premiums and deployment flexibility benefits for fast-build asset types under some scenarios. This would be particularly useful in future outcomes where market reforms and coordinated energy policies fail to eventuate, causing individual states to react to localised system events. This is already being demonstrated by recent announcements in NSW and Victoria following the summer bushfires – where deployment speed and flexibility becomes more critical in driving the generation mix and network build timeframes.

- **Optionality** – Similarly, it could be valuable to include a scenario that demonstrates the benefits of optionality – e.g. assessing what the impact of a paused or delayed Snowy 2.0 would look like, or whether non-network alternatives can sufficiently defer the need for non-priority transmission upgrades until more certainty on generation uptake is obtained. Modelling the value of alternative options deployed more rapidly and at smaller scale (at least for one scenario) would provide a helpful counterfactual to the preferred least-cost/long-term outcome and be helpful for policy design considerations.