TESLA

Transgrid: Meeting System Strength requirements in NSW

March 2023

Tesla submission to PSCR

LAST EDITED
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Sent via email to: regulatory.consultation@transgrid.com.au

30 March 2023

Dear Transgrid team

Tesla Motors Australia, Pty. Ltd. (**"Tesla"**) welcomes the opportunity to provide Transgrid with a response to the Project Specification Consultation Report (PSCR) in respect of the RIT-T to address a system strength shortfall in the transmission network at Newcastle and Sydney West, forecast to arise from 1 July 2025, as well as the ongoing provision of system strength services from 2 December 2025. Tesla's mission is to accelerate the world's transition to sustainable energy. A key aspect of this will be using smart, grid-forming inverters to support increased penetration of variable renewable energy (VRE) in the grid. We believe that battery energy storage system (BESS) assets, particularly Tesla Megapacks operating with our virtual machine mode (VMM) technology, will be integral to providing a scaled, cost-effective system strength solution in all Australian jurisdictions.

Tesla is particularly supportive of Transgrid's approach of seeking non-network expressions of interest to accompany the RIT-T process. Grid-forming inverters, and BESS assets in particular, provide a solution that can be optimised in the long-term for both market and system strength services. We believe that non-network solutions have the following benefits over the alternative network solutions that Transgrid has also considered in their PSCR, specifically:

- Non-network solutions such as grid-forming batteries provide a multitude of market services as well as network support to make them more cost effective than other solutions. Given the flexibility of BESS to have features and functionality updated over the asset life, these services can also change over time to provide optimal co-benefits to the grid and the market.
- Grid-forming BESS assets support the broader NSW Energy Security Target (EST) and aligns with complementary policy development work that the NSW Government, EnergyCo. and AEMO Services are managing. It also aligns with the broader federal priorities of developing a capacity investment scheme.

Grid-forming BESS assets also meet all of the technical characteristics of the non-network solutions outlined by Transgrid. However, it is important to note that once grid-forming mode (such as VMM) is enabled at the point of grid connection, then BESS assets will provide ongoing system strength support without any need to respond to external enablement signals. This means that non-network solutions can provide system strength whilst also optimised for market needs at any point in time – performing a number of different functions simultaneously. This further improves the commercial viability of grid-forming BESS assets as a non-network solution. Tesla has mature grid models available for grid-forming Virtual Machine Mode in both RMS and EMT environments which have been the subject to the rigorous assessment under NER 5.3.4A/B and 5.3.9 for NEM connected projects.

Tesla has previously worked with Transgrid in delivering the Wallgrove BESS, including the enablement of grid-forming functionality through a 5.3.9 process and believe that this model provides a good base case of what could be provided at scale. Grid-forming batteries are a readily available, off-the shelf solution that can be deployed rapidly at scale, as fast or faster than many alternative solutions and Tesla is capable and willing to support a portfolio of **grid-forming BESS assets** to meet the system strength requirements outlined in the PSCR and support the connection of 15GW of VRE in NSW.

For more information on any of the content included in this response to the PSCR please contact Emma Fagan [redacted]

Kind regards - Emma Fagan

Contents

1. i. About Tesla

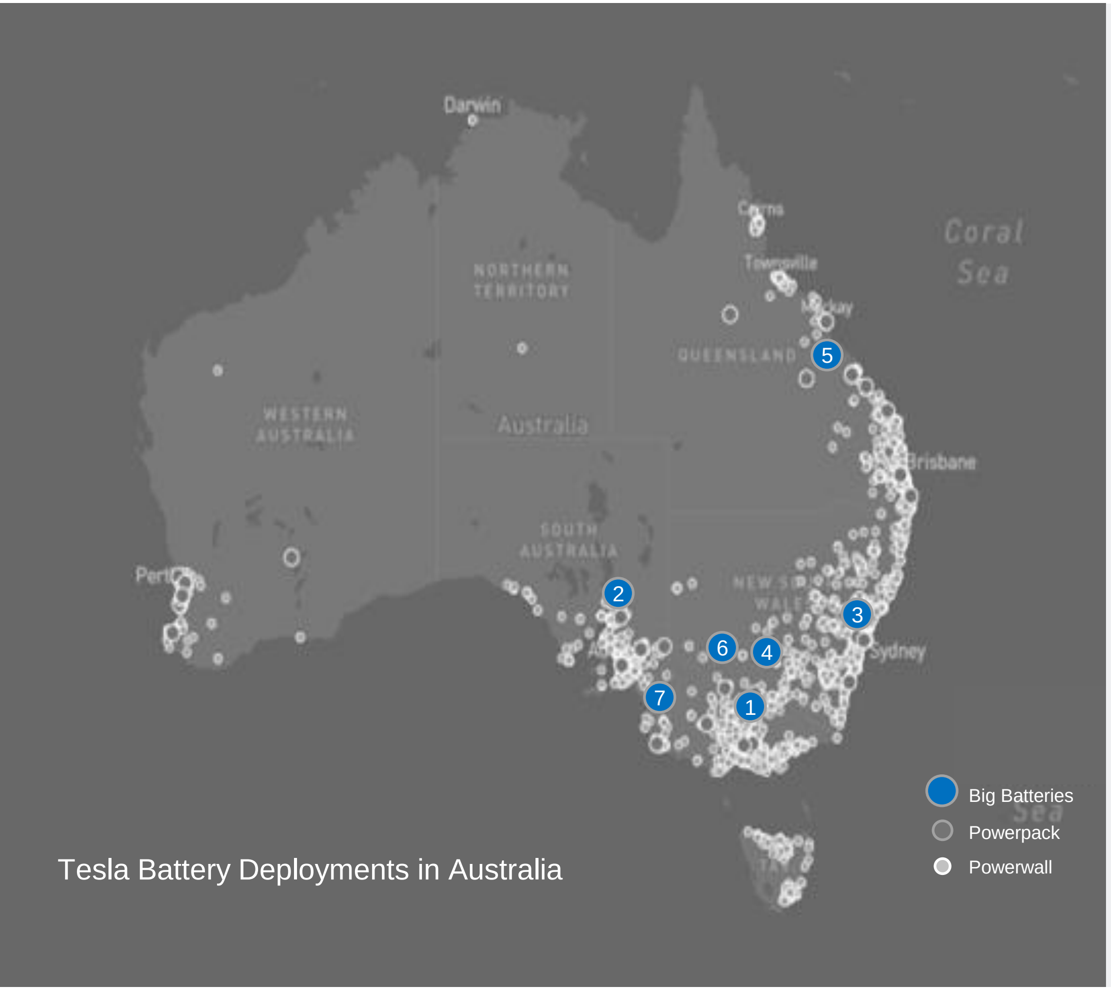
- Tesla is a global leader in manufacturing EVs and clean energy products, producing a unique set of energy solutions such as Powerwall and Megapack in a vertically integrated manner, enabling homeowners, businesses, and utilities to manage renewable energy generation, storage and consumption. Globally, Tesla has deployed over 7GWh of residential and utility scale energy storage across 40 countries, with 3.5GWh of storage deployed in 2021 alone

- Tesla Motor's Australia, Pty. Ltd. (TMA) is a wholly owned local subsidiary of Tesla, Inc. and has grown rapidly to now comprise around 500 personnel covering our electric vehicle sales and service, charging infrastructure deployments, and all scales of battery storage. Tesla is the leading provider of battery storage in Australia, playing a key role in the transition to higher penetrations of renewable energy in the National Electricity Market. We have deployed more than 1GWh of storage assets since 2017 – including the 150MW/194MWh Hornsdale Power Reserve (HPR), which was commissioned in late 2017 and expanded in 2020. HPR is still one of the largest battery storage system in the world and now with grid-forming capability, is running an inertia trial, critical to supporting the NEM's energy reliability while helping to achieve net zero emission ambitions

- Tesla is also a leader in delivering high quality Virtual Power Plants (VPP). The South Australia VPP (delivered by Tesla and Energy Locals) has over 20MW registered capacity

- Our proprietary bidding software – Autobidder – is used by several batteries across the globe, including in the NEM; Tesla has also developed Virtual Machine Mode to provide a range of network services, traditionally provided by synchronous machines

1. ii. Tesla's footprint experience in Australia – over 1GWh deployed



Tesla Battery Deployments in Australia

1. Victoria Big Battery (Neoen): 300MW / 450 MWh | Geelong, Victoria

- Key applications: System Integrity Protection Scheme (SIPS), energy and FCAS. GPS is currently being modified to enable VMM via 5.3.9 (with support from ARENA advanced inverters funding program)

2. Hornsdale Power Reserve (Neoen): 150MW / 194 MWh | Jamestown, South Australia

Key applications: energy, FCAS, and Inertia with grid-forming inverter trial (***see case study***)

3. Wallgrove Grid Battery (Lumea): 50MW / 75MWh | Sydney, New South Wales

Key applications: energy, FCAS, and Inertia with grid forming-inverter trial (***see case study***) VMM is now operational on the facility

4. Riverina Energy Storage System (Edify): 150MW / 300MWh | Darlington Point, New South Wales

Key applications: energy, FCAS, and Inertia with grid forming-inverter (achieved via 5.3.4a)

5. Bouldercombe (Genex): 50MW / 100MWh | Queensland *(operational in 2023)*

Key applications: energy and FCAS – Tesla operating under revenue share arrangements

***6.* Gannawarra (Edify):** 25MW / 50 MWh | Gannawarra, Victoria

Key applications: energy and FCAS, contracted to Energy Australia

7. Lake Bonney (Iberdrola Australia): 25MW / 52 MWh | Lake Bonney, South Australia

Key applications: energy and FCAS

1. iii. Summary benefits of grid forming inverters

Tesla believes that grid-forming inverters operating with Tesla's Virtual Machine Mode "VMM" should form an integral part of the future management of system strength in NSW and all other Australian jurisdictions. Tesla is confident that we can support Transgrid in the following areas:

a) **accelerate demonstration of advanced inverter capabilities -** Virtual Machine Mode (VMM) is a 'grid-forming' feature implemented on Tesla inverters that mimics the behaviour of traditional rotating machines. VMM is currently operational at Hornsdale Power Reserve in South Australia, the Wallgrove Grid Battery in NSW and shortly at the Riverina Energy Storage System in NSW, making Tesla one of the few technology providers in Australia with in-market experience of using inverter-based BESS assets to provide a demonstrable inertial response, via active power. BESS assets can also act as a viable alternative to network infrastructure, providing voltage and system strength support via reactive power.

b) **Continuous improvement of performance -** The wealth of operational data that Tesla continues to collect from all projects can provide NSPs and AEMO with confidence in our capabilities to meet and demonstrate the technical requirements, and provide long-term inertia and system strength support from advanced inverter technology. Unlike traditional network solutions, Tesla can continuously improve our product performance and make iterative updates via software or firmware changes.

c) **reduce the reliance on synchronous assets for system stability –** As trials and pilots expand and scale across Australia, BESS with grid-forming inverters are being recognised for their ability to provide a suite of essential system services, including system strength, voltage control, virtual inertia, and system re-start services. Tesla has global experience in providing a wide range of different technical services, and we ensure that we are constantly looking forward to future market needs. As a result, Tesla has substantial demonstrated technical capability in providing services that are not yet capable of being monetized (e.g. very fast frequency response, inertia, voltage control and harmonic stability)

d) **optimised market and network support services –** non-network solutions such as Tesla grid-forming BESS assets can be fully optimised to also provide market services. This both reduces the costs associated with managing a portfolio of system strength assets, and also ensures that the assets are providing energy capacity and other critical market and grid supporting services.

e) **scaled deployment and reduced investment in critical energy infrastructure-** Tesla's vertical integration means we are constantly developing local knowledge and skills in Australia in emerging and critical areas and is committed to sharing this knowledge to support our mission of *accelerating the world's transition to sustainable energy*. The accelerated uptake of utility scale BESS projects is, and will be, well supported by existing and announced state and federal energy policies. This further reduces costs and avoids over-investment in critical infrastructure. We firmly believe that assets that can be deployed to provide multiple purposes, should be. Single-use assets add costs to all Australian energy consumers.

f) **inform the market regulatory bodies –** Tesla has a strong track record working with project partners across past ARENA projects in delivering on knowledge sharing commitments, supporting and collaborating with policy makers, regulators, funding bodies, and system planners in recognising the value and services provided by battery storage and advocating for requisite market and policy changes through data-driven analysis, further accelerating the uptake of renewable energy in Australia

2. i. Commercial benefits of non-network solutions

Tesla believes that grid-forming inverters operating as a non-network solution can meet all of Transgrid's system strength solutions and provide a superior commercial solution to traditional network solutions such as synchronous condensers. These benefits include:

- Grid forming BESS projects can be optimised for market and network solutions. This reduces the overall cost of the non-network solution as the system strength service can effectively be provided as an additional service that operates in the background while the battery is concurrently providing other market services. This reduces the commercial ask for the non-network service as the battery is also being fully utilised in all existing markets.

- BESS assets can also change priorities over time. This is important as additional markets are expected to come online over the next five years which will provide additional revenue streams to batteries. This results in assets that are more flexible and able to adjust to changing market needs and requirements, as well further improving the market economics of non-network solutions. This could result in conditional non-network service payment adjustments in the future as these new revenue sources come online.

- Grid-forming BESS are also completely aligned with the direction of both NSW and federal policy objectives. Deploying grid-forming BESS projects can support the NSW Energy Security Target and the state goals of 2GW of storage capacity. The firming LTESA tender process which commences in April will likely result in a number of projects that can provide NSW system strength services. In respect of the future deployment of 29 synchronous condensers, the federal capacity investment scheme will also likely drive the uptake of more storage assets. The benefits of co-optimising system strength with alternative policy mechanisms supporting capacity, is that it will also further drive down the costs of the solution.

2. i. Commercial benefits of non-network solutions (cont.)

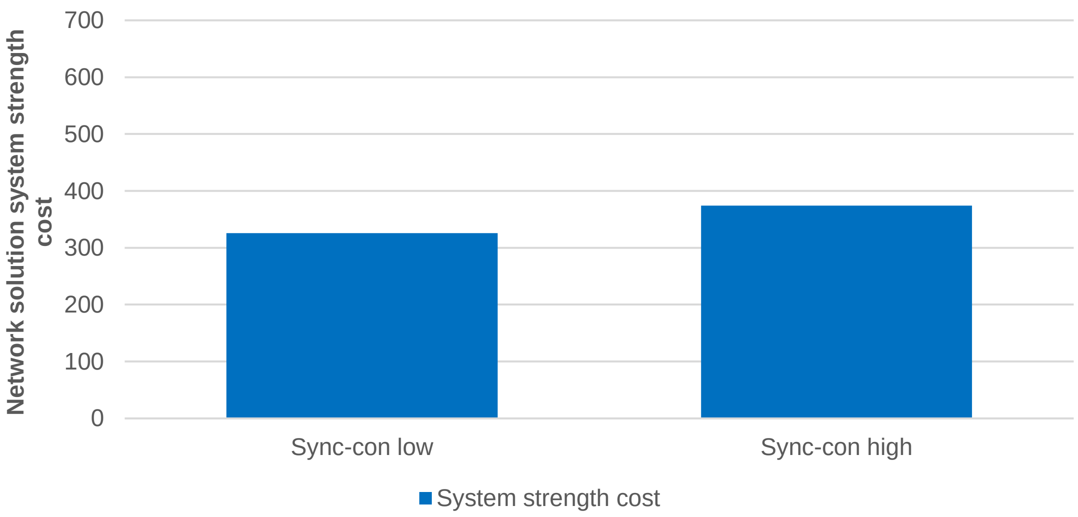
Comparison of network and non-network solutions

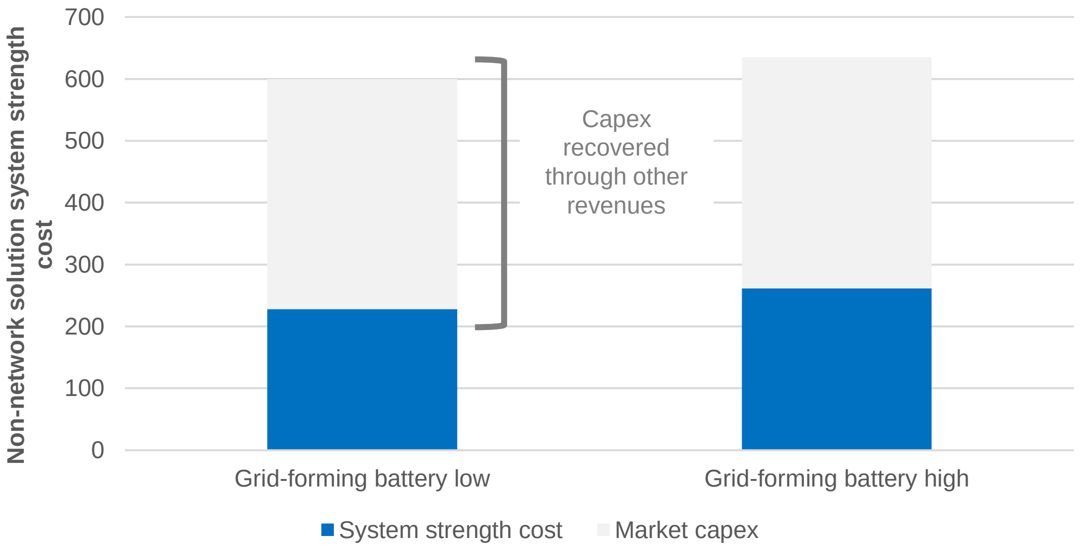
Transgrid network solution: 4 x 125MVA synchronous condenser

- **Capital cost:** $326 - 374 million[1].
- **Portion reserved for system strength:** 100%
- **Portion used for market services:** 0%
- **Additional market services provided:** N/A
- **Alignment with NSW and federal policy priorities:** REZ development priorities

4 X 125MW BESS assets (2hr duration)

- **Capital costs:** ~$600 - 635m[2]
- **Portion reserved for systems strength:** As low as 0%. Grid-forming inverter BESS asset can provide system strength services as a by-product
- **Portion used for market services:** Up to 100%
- **Additional market services provided:** Multiple – see following slide.
- **Alignment with NSW and federal policy priorities:** REZ development priorities**,** Firming LTESA, Capacity Investment Scheme.
- **Tesla is confident that a non-network solution would be at least 20-40% more affordable on an NPV basis than the network option considered [3]**





1. Per Option 1 in the PSCR.
2. Based on AEMO ISP 2023 Inputs and Assumptions Workbook "Build Costs" tab. Assuming 2hr duration and 24/25 or 25/26 deployment timeline.
3. Dependant on TNSP WACC and IRR requirements. This is also just a best estimate, and we expect that the EOI responses received will differ from this number. Tesla is happy to work with Transgrid throughout the process to continue to build expertise on the commercial benefits of BESS assets operating as a non-network solution.

2. ii. Commercial benefits of non-network solutions (cont.)

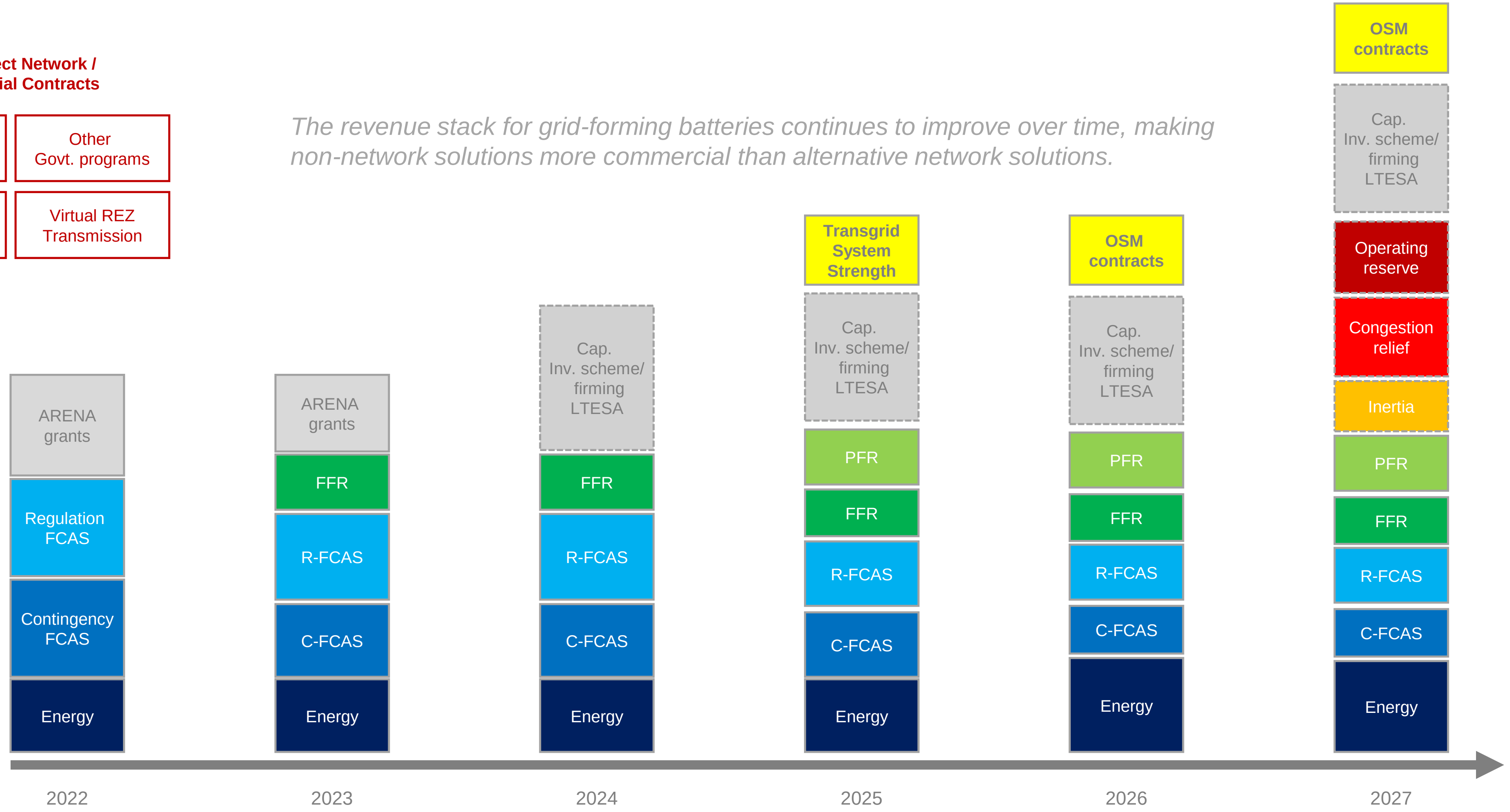
Market revenue sources for grid-forming batteries

Under development

Other Direct Network / Commercial Contracts

SIPS	Other Govt. programs
SRAS	Virtual REZ Transmission

The revenue stack for grid-forming batteries continues to improve over time, making non-network solutions more commercial than alternative network solutions.



2. iii. Alignment with policy outcomes

State and federal energy policies

Policy framework	Non- network solution (grid forming battery)	Network solution (synchronous condenser)
NSW Energy Security Target	A key component of the NSW Energy Security Target is the requirement for 2GW of storage capacity being built in NSW. By using batteries with grid-forming inverters, these assets can also be making a positive contribution to the NSW Energy Security Target and reducing the need for additional investment in storage through the long-duration storage LTESA mechanism.	Does not support the Energy Security Target
Firming LTESA	Related to the above, the NSW Government is also opening the Firming LTESA competitive tender process at the beginning of April. This tender will seek at least 380MW of firming capacity which may include grid-forming batteries. That capacity is required to be commissioned by 1 December 2025 which perfectly serves the Transgrid timelines. Given the timelines there is potential for an overlap in projects providing an EOI response to Transgrid and also tendering in the firming LTESA process. Similarly those projects that are successful in the firming LTESA process will likely be suitable for providing system strength support regardless of whether they've submitted an EOI.	No overlap between firming LTESA process and the proposed network solution.
NSW REZ development	Each of the NSW renewable energy zones has their own developmental requirement and are looking at some form of system strength support – be it through network or non-network solutions. Grid-forming batteries provide one option for supporting REZ development.	Both network and non-network options are being considered in the REZ development ongoing work.
Federal Capacity Investment Scheme	A federal capacity investment scheme will likely drive the uptake of additional storage capacity including the potential for grid forming inverters across NSW. These can be used to support system strength in the state.	Synchronous condensers are not considered as capacity and will not be an eligible technology under the capacity investment scheme.

3. i. Tesla’s Battery Applications & Technical Capability

Service/capability	Grid-following inverter system	Grid-forming inverter system	Synchronous machines
Can contribute to system strength		✓	✓[A]
Can have positive disturbance withstand (active power oscillation damping)		✓	✓
Can have positive disturbance withstand (fault ride-through capability)	✓	✓	✓
Can contribute to system inertia		✓[B]	✓
Can contribute to FFR	✓	✓	
Can contribute to primary frequency response	✓	✓	✓
Can support a power system island with supply balancing and secondary frequency response	✓	✓	✓
Can initiate or support system restoration	✓[C]	✓	✓

AEMO, “Application of Advanced Grid Scale Inverters in the NEM”, August 2021

- Large-scale battery storage systems will play a central role in all future energy systems globally, integrating their full potential will help Australia to lead the way as a renewable energy leader. This position is well recognised by AEMO with the released of their “Application of Advanced Grid Scale Inverters in the NEM” White Paper in August 2021

- Virtual Machine Mode (VMM) is a ‘grid-forming’ feature implemented on Tesla inverters that mimics the behaviour of traditional rotating machines. Increasingly, battery systems with grid-forming inverters are being recognised for their ability to provide a suite of essential system services, including system strength, voltage control, virtual inertia, and system re-start services (see following slides for additional technical detail)

- VMM is currently being used at Hornsdale Power Reserve in SA and Wallgrove Grid Battery in NSW, making Tesla one of the few technology providers in Australia with in-market experience of using inverter-based battery storage systems to provide a demonstrable inertial response, via active power. Battery storage can also act as a viable alternative to network infrastructure, providing voltage and system strength support via reactive power. The next logical step is to have a meaningful system strength demonstration of VMM

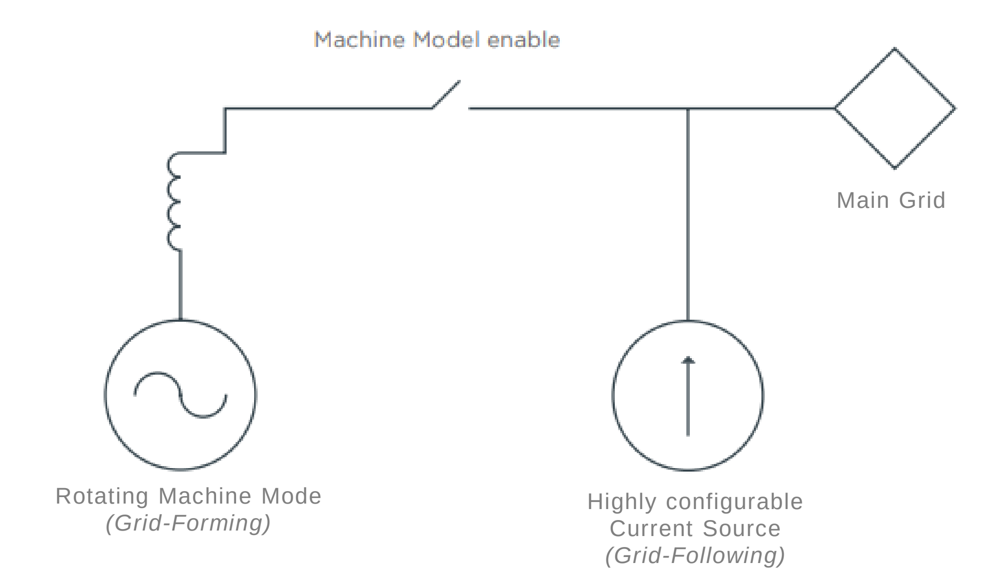
- With a commitment to innovation, all of Tesla’s energy storage projects seek to support a range of job growth opportunities and innovation activities and ultimately create new industry development that is in full support of Australia's decarbonisation goals. Tesla is committed to providing electricity consumers and tax-payers a cost-competitive solution that provides best value for money over the full terms of the services.

3. ii. Tesla – Virtual Machine Mode

Inverter based system strength and virtual inertia

- Virtual Machine Mode is a feature implemented on Tesla inverters that mimics the behaviour of a traditional rotating machine. The virtual machine component runs in parallel with the conventional current source component.
- The virtual machine is a blended mode that brings dispatchability of a current source operating in parallel with the stability benefits of a voltage source.
- Like more traditional inverters, under stable system conditions, the inverter's behaviour is driven by the current source component. The inverter charges and discharges in accordance with commands received from the operator.
- If there is a grid disturbance, the rotating component responds by producing a reactive current in response to changes in voltage and producing an active power response proportional to the rate of change of frequency (RoCoF).
- Though these features can be provided by current-source inverters in response to a predefined feedback control mechanism, the rotating component in Tesla's batteries can respond on a sub-cycle basis – responding to phase angle changes (within 10ms) rather than root-means-squared (RMS) values (within 150ms) – mimicking the electromagnetics of a synchronous generator, but with the additional benefit of flexibility and configurability of the response.

Tesla Inverter Virtual Machine Mode:
A Tesla inverter can operate in Virtual Machine Mode with a configurable current source operating in parallel with a rotating machine model (voltage source).



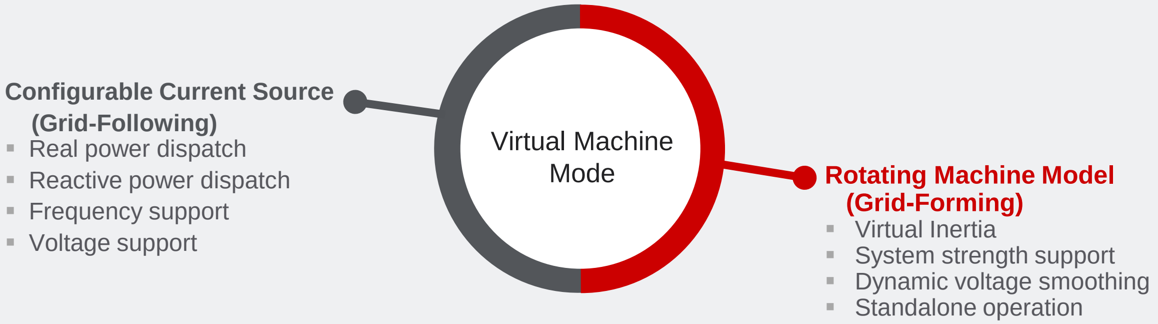
Virtual Machine Mode representation

3. ii. Tesla – Virtual Machine Mode

Inverter based system strength and virtual inertia

- Tesla Inverters operating in Virtual Machine Mode can provide inertia and fast acting voltage support to help stabilise regions of low system strength. The Rotating Machine Model component of Virtual Machine Mode responds to fluctuations in voltage with a countervailing current response. For example, if voltage suddenly drops, the machine model will inject reactive current temporarily in response. This can smooth and stabilise voltage in regions of low system strength.
- As the inverter's inertial response is created by the inverter controls, it can be modified based on the grid's needs (unlike traditional generators that have a fixed inertia constant based on their physical characteristics). Similarly, the system strength support can be configured and tuned to support the specific grid connection and regional context.
- The virtual machine model is a flexible feature that can be enabled or disabled as required. Its parameters such as inertia constant and impedance are fully configurable and can be tuned to obtain the desired dynamic behaviour for the grid. For example, the inertia constant of a Tesla battery can be configured from 0.1 to 20+ MW.s/MVA.
- In addition, inverter-based technologies can utilize their short-term overload capability to provide fault current contribution, improving the short circuit ratio at a connection point

Tesla Inverter Virtual Machine Mode
A Tesla inverter can operate in Virtual Machine Mode combining the benefits of a configurable current source and a rotating machine model (voltage source) to support grid stability in regions of low system strength.



3. ii. Virtual Machine Mode in Action

- Trialling VMM at Hornsdale Power Reserve during 2021 has allowed Tesla to provide an in-market demonstration of the performance of advanced inverter-based inertial response. For example, following the Callide C event on 25 May 2021, the contingency event resulted in an Under Frequency Load Shedding (UFLS) event in Queensland and a contingency event across the rest of the NEM

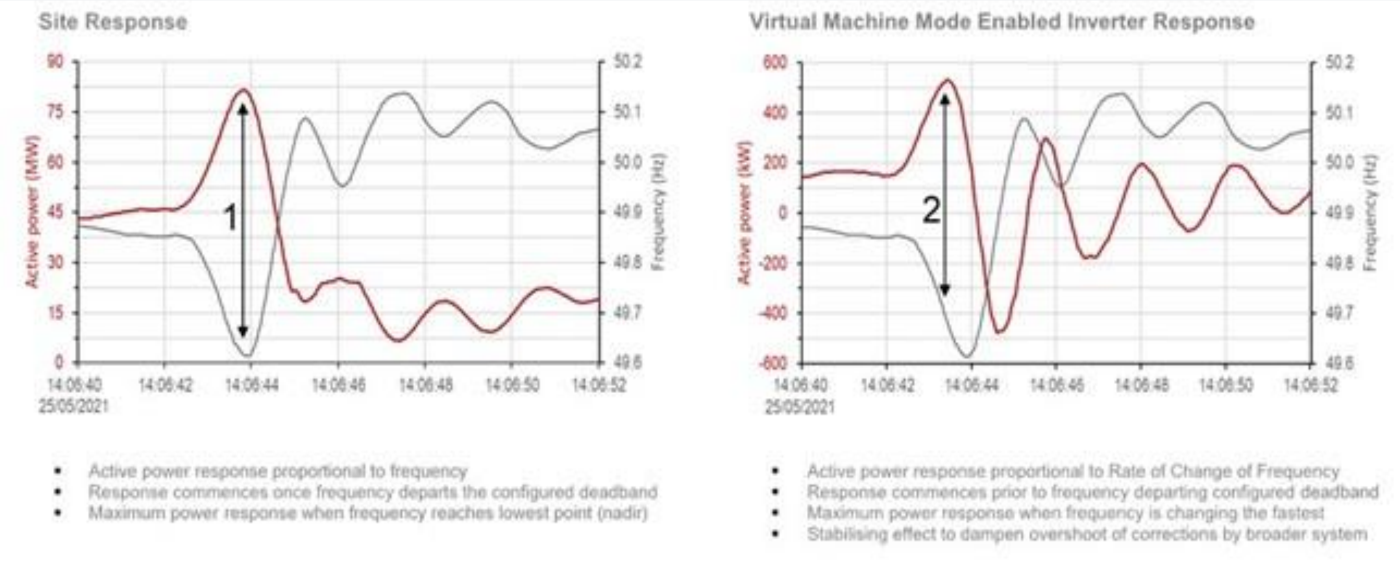
- This provided a unique opportunity to compare how inverter-based technologies respond – see figure – in standard frequency response mode (left) compared with how VMM provides an inertial response at the inverter level (right)

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

- The wealth of operational data that Tesla has provides confidence in our capabilities to meet and demonstrate the technical requirements, and provide long-term inertia & system strength support from advanced inverter technology.

Hornsdale Power Reserve – Response to Callide C event on 25 May 2021"

Site level response (grid-following) **Inverter level response for inertia trials (VMM)**



- Note: This response had only 2 single inverters enabled with VMM (for trial purpose), compared to a site level response which was predominantly non-VMM response; VMM response is isolated with Frequency/Watt response disabled to emphasise the VMM component. In reality,, the system response would be a combination of both curves - I.e. inertial response in addition to sustained frequency/watt response to recovery to NOFB

3. iii. Transgrid non-network characteristics

Grid-forming BESS assets

Criteria	Grid-forming battery alignment
Be available for enablement for 95% of each year or part of a year for which the service is offered. We will, at our discretion, consider lower availability measures where significant cost savings can be demonstrated as a result of lower availability measures	Benefits of Tesla's grid-forming Virtual Machine Mode operating mode is that once it is configured during the grid connection process the system will be providing system strength services at all times, via fast acting reactive power injection/abosrption in response to grid voltage disturbances, even when dispatched for other market purposes. There is no need to trigger or enable this service as it is inherent to the grid-forming nature of the inverter. To ensure full optimisation between the OSM and optimisation for other market purposes, Transgrid should look at the following options to maximise market benefits: • Prioritising grid forming inverters who can be configured with a grid-forming mode to provide system strength at all times. This reduces the need and complexity introduced by the need to call upon on systems for enablement and provides additional security to Transgrid. • Where systems do require a signal to trigger/enable a switch of operations in response to a signal, for example if the unit needs to reduce real power operations in order to reserve additional reactive power capability, consider seasonal enablements of such services. Given the substantial reactive power capabilities for grid connection in the NEM, it is not anticipated that capacity reservations above existing reactive power access standard requirements should be needed to provide meaningful system strength services.
Upon notification from AEMO or Transgrid to enable the services, proposed services must commit and continuously maintain the service as soon as possible from the time of the enablement request	As mentioned above, once configured during the grid connection process Tesla's grid-forming Virtual Machine Mode operating mode will be providing system strength services at all times. In addition Tesla has a 24/7 network operations centre and processes in place to immediately accept notifications from AEMO or Transgrid and have well established processes for responding to network enablement signals for dynamic services. In addition, all >5MW BESS assets are registered as scheduled assets with AEMO and will have 24/7 control room functionality. A major benefit of grid-forming batteries is the ability to rapidly respond to enablement requests for dynamic services. Services can be provided within milliseconds and where additional capacity needs to be made available, this could be managed within a short notification window. This approach has also been well proven with a number of BESS assets already able to rapidly respond to directions from AEMO or NSPs to provide services such as SIPS or fast frequency response (FFR).

3. iii. Transgrid non-network characteristics

Grid-forming BESS assets (cont.)

Criteria	Grid-forming battery alignment
Once the system strength response is enabled, the service shall remain activated until a signal to disable is received	As above, for many grid-forming inverters in market at the moment, such as the Tesla Megapack operating with VMM enabled, this will be enabled at all times. Where specific services are required, based on direction, as above, all BESS assets can disable a service as rapidly as it is enabled.
Continue to meet any relevant Generator Performance Standards (GPS) when providing the system strength support services	Non-network projects will benefit from the continued efforts of industry using the insights from HPR and other grid-scale batteries that have been operating in market in grid-forming mode for several years. These insights have been provided to AEMO and the AEMC and have influenced rule changes such as the Reactive Current rule change, which makes it simpler for new BESS assets to meet GPS requirements while providing critical system strength services.
Have facilities to transmit specified measured quantities via SCADA to AEMO and/or Transgrid's control room which conform to the required standards of reliability, accuracy and latency as would be applied to a scheduled generating system	All utility scale BESS assets will have appropriate SCADA facilities. Note that for system strength services, high resolution power quality metering is typically required for observation or validation of services provided. This data is typically recorded on site and is retrievable for specific events of interest, however it should be noted that this high resolution data is not typically made available via real-time SCADA interfaces.
Have metering facilities suitable for resolving any compensation payments associated with the provision of services;	All utility scale BESS assets will have appropriate metering on site. Once the system is configured for operation in grid-forming Virtual Machine Mode, plant availability should become the main metric for performance, with occassional validation of system response to significant grid distrubance events.
If new solutions, be supported by simulation models that comply with the requirements stipulated in AEMO's Power System Model Guidelines. This includes the provision of Electromagnetic Transient (EMT) models for power electronic interfaced equipment, including Battery Energy Storage Systems; and	Tesla has mature grid models available for grid-forming Virtual Machine Mode in both RMS and EMT environments which have been the subject to the rigourous assessment under NER 5.3.4A/B and 5.3.9 for NEM connected projects.
If a generation service is proposed (either standalone or in conjunction with other services), the system security service will be required to operate "on demand" at certain times to satisfy Transgrid's power system security requirements. Such operation will be required regardless of the pool price at the time.	As noted, once configured during the grid connection process, Tesla's grid-forming Virtual Machine Mode operating mode will be providing system strength services at all times. Additionally, BESS assets can rapidly respond to any signals sent by AEMO or the NSP and are able to constantly prioritise output. BESS assets are already adept at providing system security services and will be able to prioritise grid needs over wholesale energy market price for a particular interval where required.

3. iv. Case Study: demonstrated value for money from batteries providing grid-forming services

- As part of the funding agreement for the Wallgrove Grid Battery project, TransGrid (now under Lumea arm) commissioned independent analysis to quantify "the benefits of the regulated expenditure in the event that the R&D project successfully demonstrates the ability of batteries to provide inertia services"
- As noted by Lumea, *"The Wallgrove battery is the first grid-scale battery in NSW that will pilot the use of synthetic inertia as a network service. These network services help to stabilise the grid, and will become increasingly integral to enable the increase of renewable generation to safely connect to the grid.*
- *As well as grid-scale synthetic inertia, the battery will offer energy arbitrage and FCAS market services that generators need to optimise and firm up energy supply. Research and results from the trial will be shared to support future projects and help demonstrate that battery technology is a low cost and technically viable solution to the emerging challenge created by the transformation of the generation sector."*
- It is expected that the value of these services will only increase as more thermal generators retire and market changes are made to incentivise and reward all fast acting and flexible frequency, voltage and inertial responses that batteries can offer. Over time, these non-energy services should increase their proportion of the value stack, particularly as regulatory reforms unlock more markets to value the services being provided

3. iv. Case Study: Wallgrove Grid Battery

Customer: Lumea

Location: Western Sydney, NSW

Project Size: 50MW | 75MWh

Applications:

- **Inertia services - VMM is now operational on the facility**
- Fast Frequency Response
- Wholesale Market Participation
- Frequency Control Ancillary Service (FCAS)

Commissioned: 2021

3. iv. Case Study: Hornsdale Power Reserve

- In 2017, Tesla was selected to deploy what was the world’s largest battery energy storage project, the 100 MW/129 MWh Hornsdale Power Reserve Project in South Australia which was completed in 5 months (within 100 days of grid connection being finalised) under global public scrutiny. The project has exceeded expectations both technically and financially in operation
- In 2020, Neoen and Tesla received backing from ARENA, CEFC and the SA Grid Scale Storage Fund to expand Hornsdale Power Reserve by 50% to 150 MW / 194 MWh – maintaining its crown as Australia's largest battery while expanding its suite of system support services
- Hornsdale has been the first grid-connected battery in the NEM to trial Virtual Machine Mode, proving its capability as a provider of inertia services, voltage control and fast frequency response
- Through this trial, Tesla has demonstrated the ability of batteries to provide inertia as an alternative to synchronous machines
- The Hornsdale Power Reserve can provide up to 3,000MWs of inertia to the local South Australian grid, an estimated 50% of the total inertial requirement in the State

3. iv. Case Study: Victorian Big Battery

Customer: AEMO and Victorian Government

Location: Moorabool, Victoria (near Geelong)

Project Size: 300MW | 450MWh

Applications:

- **VMM is currently being enabled via 5.3.9 modification (with support from ARENA advanced inverters funding program)**
- System Integrity Protection Scheme (SIPS):
  250MW / 125MWh reserved: (1 Nov – 31 March)
- Wholesale Energy Market Participation
- Frequency Control Ancillary Service (FCAS)

Commissioned: 2021

3. iv. Case Study: Riverina Energy Storage System “RESS”

Customer: Edify Energy

Location: Riverina, NSW

Project Size: 150MW | 300MWh total, made up of three smaller BESS connections

- RESS 1: 60MW 120MWh – Shell & NSW Gov offtake
- RESS 2: 65MW 130MWh
- DPESS: 25MW 50MWh – VMM enabled

Applications:

- **DPESS has an approved 5.3.4A utilising VMM**
- Wholesale Energy Market Participation
- Frequency Control Ancillary Service (FCAS)

Commissioned: Currently Under Construction

TESLA