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Central-West Orana REZ Access Scheme Issues Paper

Tesla Response

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30 April 2021

RE: Central-West Orana Renewable Energy Zone Access Scheme Issues Paper – Tesla Response

Dear Chloe,

Tesla Motors Australia, Pty. Ltd. (Tesla) welcomes the opportunity to provide a response to the NSW Central West Orana Renewable Energy Zones issues paper, and wholeheartedly supports the NSW Government's vision to deliver Renewable Energy Zones across the state in a way that maximises benefits for consumers, and mitigates risks for developers.

Tesla is encouraged by the early engagement and transparency provided on the access scheme design, allowing stakeholders the opportunity to help refine and provide feedback on the proposed options. In particular, Tesla is strongly supportive of NSW's aims to ensure 2GW of new storage capacity is facilitated under the Electricity Roadmap, recognising the critical role storage plays in NSW's future grid. However, 8-hour duration requirements for storage are both unnecessary, and inefficient. As a proven and commercially competitive technology, shorter-duration battery storage systems can underpin the government's ambitions for REZs, providing lower cost, greater deployment flexibility, critical services such as system strength, and better performance than alternative solutions such as traditional network build or deployment of synchronous condensers. This approach would also maximise benefits back to local communities and provide a catalyst for jobs growth in technologies of the future.

Tesla's key recommendations on the Issues Paper include:

1. **Recognition of the role storage will play providing virtual inertia and system strength, underpinned by a contestable procurement approach for these essential network services**
2. **Prioritisation of network investment (including non-network options such as storage), to address immediate connection and system strength constraints impacting renewables**
3. **Consideration of access regimes exemptions for storage locating within REZs, in addition to driving centralised storage assets and additional locational incentives for REZ storage**
4. **More detail on the potential interactions with the other elements of the NSW Electricity Roadmap and NEM-wide schemes, including how long-term energy service agreements might apply**

Tesla's mission is to accelerate the word's transition to sustainable energy. As such, Tesla is committed to continuing its work in NSW, to ensure the delivery of secure, reliable, sustainable and affordable electricity to all NSW consumers now and into the future. We commend the NSW Government for continuing to lead the development and planning for grids with integrated renewable and storage solutions and we look forward to collaborating towards this shared ambition.

Kind Regards

Emma Fagan - Head of Energy Policy and Regulation

REZ Storage Integration Recommendations – Summary

1. **Integration of storage is a necessary and highly beneficial step for REZ development and additional incentive mechanisms should be explored to accelerate deployments**

- Integration of storage into the CWO REZ and NSW grid is aligned with all objectives – investment certainty for generation (with firming and essential services), efficient network utilisation, improved connection process, provision of network services including local system strength support, improved competition, and downward pressure on electricity prices
- Noting the market still undervalues the suite of fast and flex ble services provided, NSW could explore a contestable procurement mechanism for essential system services to support projects

2. **Storage should be exempt from any financial or physical limits and not directly involved in access right regimes (acquiring rights or paying compensation)**

- Storage plays multiple roles beyond simply time-shifting energy services – e.g. its ability to provide system strength and inertia (as demonstrated by TransGrid's Wallgrove Grid Battery), voltage support, and enable additional REZ connections whilst mitigating potential congestion within and around the REZ
- In market dispatch, a large share of storage participation is in ancillary services – so careful consideration is needed to avoid solving thermal capacity congestion issues whilst creating system security issues. In addition, storage optimisation is already aligned with providing the most valued service when it is most needed. Unless there are contingency or extreme weather events, storage will always be incentivised to charge when prices are low (and renewable generation abundant), whilst offering all ancillary and system services in parallel
- Rather than forcing generator requirements onto storage, the focus should be on ensuring appropriate incentives are in place for storage to locate within REZs. In this context, there is little downside risk to integrating 'excess' storage capacity, so care must be taken to overcome existing investment barriers without introducing more – e.g. potential costs from access rights, low capacity thresholds, or additional operating restrictions – otherwise storage projects will simply locate elsewhere in the shared network (given their much greater deployment flexibility and relatively streamlined network connection) and/or rely more heavily on (location neutral) LTESAs
- The Victorian REZ Development Plan provides a useful comparison framework that positions storage as an enabler for renewable connections, rather than treating it as additional generation capacity. With this lens, it is critical that storage is exempt from any restrictive capacity threshold requirements or obligations to purchase access rights (or compensate generators who have)

3. **8-hour duration requirements for storage (as defined in the Electricity Infrastructure Investment Bill 2020) are both unnecessary and inefficient for REZ developments**

- It is unclear why or how this 8-hours figure was determined, but based on market and system needs, enforcing it would drive over-investment in long-duration storage for firming, when shorter duration fast response battery storage would still be required to provide essential system services such as system strength, inertia and fast frequency response. NSW Government can work with industry to provide for additional flexibility in the regulations - e.g. create a NSW Roadmap register that allows the same 400MWh storage system to register with 8 hour dispatch capacity (50MW / 400MWh); in parallel to AEMO's central dispatch registration based on total nameplate capacity (200MW / 400MWh) to satisfy Part 5; Clause 36 (1)(b)(i) in the Act
- This approach aligns with the technology neutrality principles – seeking required services rather than specific technology types or overly conservative assumptions on duration requirements. As is currently the case for participating in energy and ancillary services – there should be no difference in treatment between long and short duration assets – operators will simply need to manage bids and charge levels themselves

4. **NSW Government can coordinate an initial centralised REZ storage project, to ensure sufficient system security and resiliency and facilitate shovel ready projects from 2022**

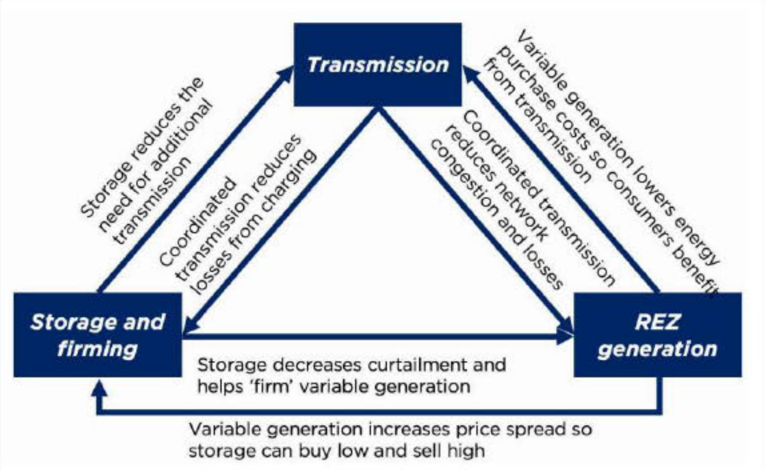
- Coordinating central storage assets could de-risk the CWO REZ scheme and the entire NSW Electricity Roadmap by providing capital efficient storage deployment. This will help to address existing barriers and ensure delivery of location specific services (e.g. system strength) that cannot be easily or efficiently provided from other assets on the shared network
- Centralised grid-forming battery storage could also streamline the connections process by delivering system strength, inertia, and other services in a coordinated way, allowing TransGrid and AEMO to progress necessary grid studies in advance of connection – this will further incentivise generation projects to locate within REZs and purchase access rights

Access Right Design Considerations - Summary

- In designing access schemes to manage congestion, NSW should consider higher weightings for policy simplicity. For example a new option (Option 0) could prioritise and accelerate network investment with a 'light-touch' access regime that excludes storage (e.g. bid bonds or initial entry fees for CWO REZ generators), in return providing enhanced information sharing, access to a portion of storage capacity, MLF protection, and faster connection
- Given the uniqueness of storage (not a true generator or load) and multiple services provided, access rights do not need to apply to storage to incentivise optimal dispatch (and charging) to reduce congestion and increase network efficiency. This approach would also avoid placing restrictions on non-energy services (i.e. FCAS, system strength, inertia, voltage etc.) which are critical to supporting the uptake of renewables and providing system security in the REZ and NEM more broadly
- All access options have challenges for all generation types. Most significantly, shared network congestion remains a risk.
- More specific to storage, if access schemes do apply – some key issues to manage include:
    - Option 1 - Physical
        - Setting optimal capacity thresholds will be a key challenge. If storage capacity is capped, it may limit (/increase costs of) provision of essential system services
        - Co-located storage opportunities could be hampered since individual wind/solar projects will have access rights guaranteed despite being 'non-firm', especially if hybrid system's aggregated capacities are included towards their cap. Access to a centralised storage asset may address this risk
        - Hard to introduce other locational mechanisms to incentivise co-located storage without a broader financial regime
    - Option 2 – Financial
        - Requiring stand-alone storage to purchase access rights can undermine the entire business case for battery storage – will need large benefits to incentivise REZ location
        - Commercial return for storage is at risk if penalised from participating during peak price periods (noting a few intervals drive large proportion of annual revenue)
        - If storage access rights are allocated in defined blocks – this can limit flexibility of storage to optimise and provide most valuable services (energy + non-energy) when required
        - 2B's enhanced (time-variant) rights may remove impetus to co-locate storage – since solar projects would only have daytime access rights sized at nameplate capacity
- We are keen to explore NSW Government's appetite for a network expansion model with light touch access provisions that exclude storage from the regime – we believe this would still solve current network issues, achieve all objectives but avoid introducing additional complexity and financial barriers for storage assets to support REZs. Unlocking the value of assets deployed would also maximise benefits back to local communities and provide a catalyst for jobs growth in technologies of the future

2GW of grid-scale storage required across NSW by 2030, with up to 1GW needed in CWO region

- We understand the NSW Electricity roadmap will drive 12GW of new renewables and **2GW long-duration storage** (in addition to Snowy 2GW and behind the meter storage) through long-term energy services agreements (e.g. CFDs)
- CWO REZ targeting 3GW of renewable capacity. This implies **750MW to 1GW of storage needed in CWO region** to proportionately support the REZ (typical renewables to storage ratio is around 4:1), providing all energy, essential and network services required. Grid-forming battery storage can also defer expenditure on traditional network assets (poles, wires, syncons etc).
- Current NSW (publically) announced pipeline of battery projects totals 4.5GW, but only 335MW are committed and many announced projects typically do not reach financial close
- The geographic spread of storage projects also shows there is currently 0MW proposed for the CWO region (see next slide) – which puts 2022 shovel ready timelines at risk (we note the NSW Government has greater visibility of concept / planning stage projects and a view on registered interest from the CWO ROI process)
- Apart from TransGrid's 50MW Wallgrove Grid Battery, all other storage projects are developer led, with business cases based on providing market services (energy & FCAS) – and unlikely to factor network service provision such as system strength, voltage support, inertia etc. given the current difficulties in monetizing these services. This is likely driven by the inherent barriers to non-network options within the RIT framework

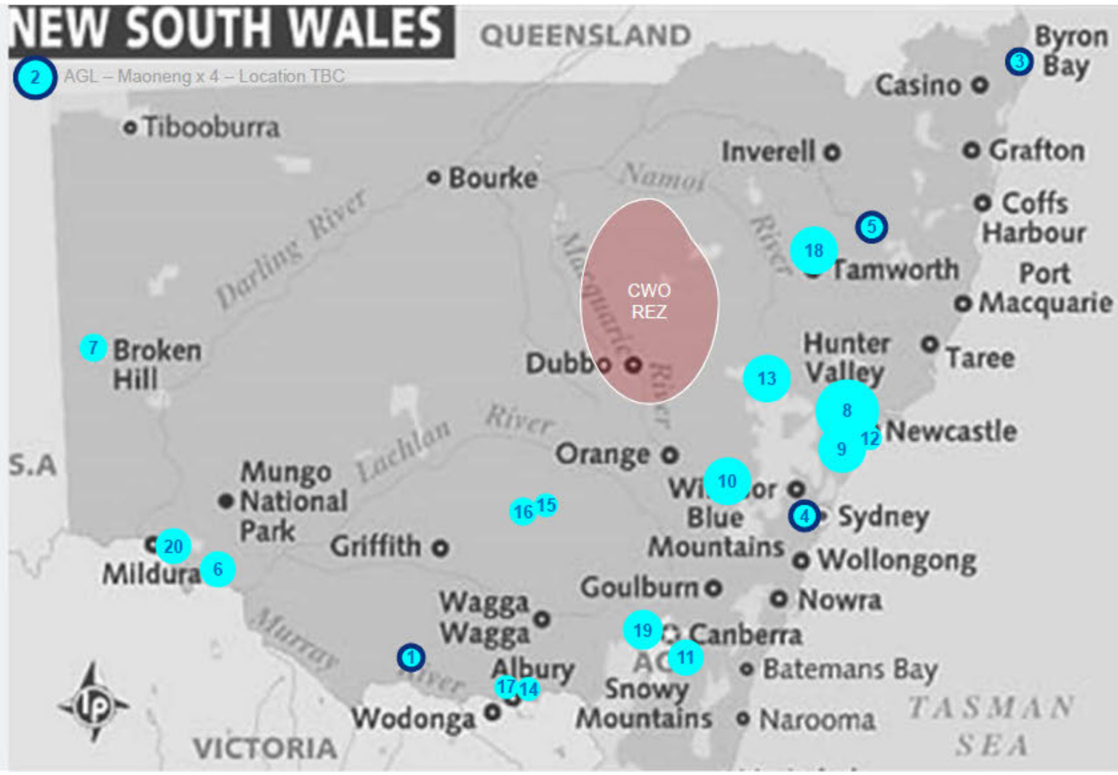


NSW Electricity Roadmap – 'whole of system' approach

NSW storage pipeline totals 4.5GW (335MW committed), but 0MW proposed for CWO region

	Project Name	Status	Owner	MW	MWh
1	Sapphire Renewable Energy Hub	FID	CWP Renewables	30	30
2	Maoneng x4	FID	AGL Energy	200	400
3	Byron Bay Solar Farm	FID	Coolamon Energy	5	5
4	*Wallgrove Grid Battery*	*FID*	*TransGrid*	*50*	*75*
5	New England Solar Farm	FID	UPC	50	50
6	Sunraysia Emporium	Proposed	Maoneng	100	200
7	Broken Hill BESS	Proposed	AGL Energy	50	
8	Hunter Battery	Proposed	CEP Energy	1200	
9	Eraring Battery	Proposed	Origin Energy	700	
10	Great Western Battery	Proposed	Neoen	500	1000
11	Capital Battery	Proposed	Neoen	100	200
12	Steel River Battery	Proposed	Precinct Capital /Edify	28	56
13	Liddell Battery	Proposed	AGL Energy	500	
14	Hume BESS Project	Proposed	Meridian Energy	20	
15	Wyalong Solar Farm (BESS)	Proposed	ESCO Pacific	25	25
16	West Wyalong Solar Farm (BESS)	Proposed	Lightsource BP	50	90
17	Jindera Solar Farm (BESS)	Proposed	Jindera Pty	30	60
18	Thunderbolt Energy Hub	Proposed	Neoen	500	
19	ACT BESS	Proposed	Neoen	300	
20	Sunraysia Emporium	Proposed	Maoneng	100	200
			TOTAL	4538	

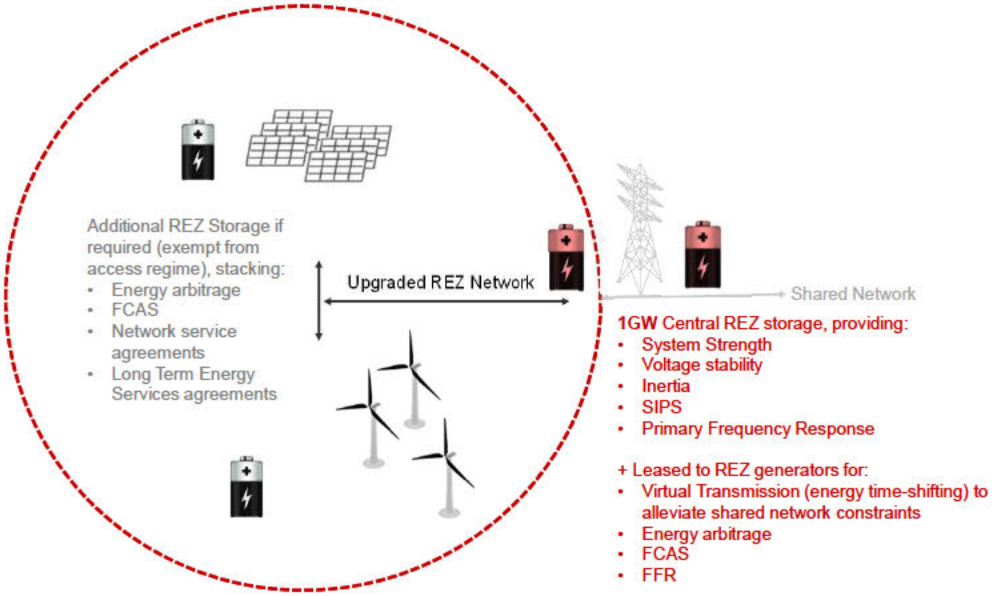
Note: NSW Government will have greater visibility of concept / planning stage projects not yet public and a view on registered interest from the CWO ROI run previously



NSW Battery Storage Pipeline
(Committed & Announced)

Electricity Roadmap and REZ scheme – Recommended Storage Policy Design

- **Target up to 1GW of storage for CWO REZ**
- Coordinated deployment initiated by NSW Energy Co and/or TransGrid for CWO Central REZ battery storage project, to ensure sufficient system strength, inertia, voltage support, and resiliency across the region and to facilitate shovel ready projects from 2022
- The battery should be over-sized to leverage economies of scale, and then effectively partitioned and leased to renewable developers seeking a share in energy storage market services - whether owned by the REZ coordinator, TransGrid, private companies, or some combination – which provides a clear locational incentive for wind and solar projects to locate in the REZ (and benefit to their purchase of access rights)
- This model still allows for innovative operating models, but requires NSW to ensure a fit-for-purpose New Efficiency Test that supports funding for non-network options and recognises the multiple benefits provided to multiple parties (currently not captured under the AER's RIT-T framework)
- Additional de-centralised storage assets could still facilitated (both stand-alone & co-located) to provide additional services if required. However, this relies on appropriate locational incentives and exemptions from access rights, to maintain the commercial case for individual renewable projects to further firm output, enable greater market competition, and stabilise MLFs
- All forms of REZ storage can provide network services with appropriate procurement mechanisms (previously only provided by synchronous generators, network upgrades, or syncons) – aligning with the TransGrid rule change seeking a more coordinated system strength standard. It would also provide network deferral and optionality benefits, and provide greater value than syncons
- If access rights are imposed without additional incentives for REZ battery storage, the costs/risks of locating within the REZ would outweigh the benefits (noting the LTESA for storage is designed as location-neutral)



CWO REZ
Illustrative Storage Integration

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i. Benefits of battery storage

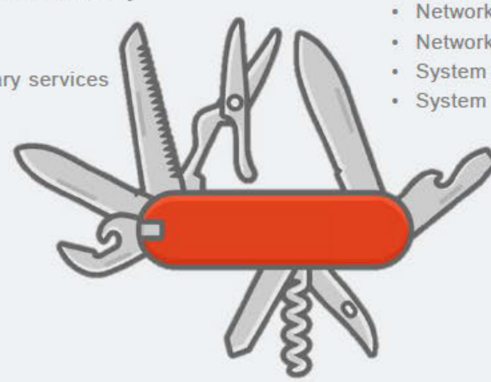
Battery storage systems are a facilitator of an efficient REZ scheme – supporting all objectives

- The NSW Government has recognised the importance of REZs and the range of benefits they provide to support the transition from ageing thermal generators towards a cleaner, more reliable, and more affordable energy future
- The wide spectrum of benefits provided by battery projects shows strong value potential for both market participants, the system and network operators, and NSW consumers
- In contrast, site or technology specific solutions such as synchronous condensers may only provide some categories of benefits, and at much smaller scale. We recognise AEMO and network service providers have extensive experience with these traditional assets, but this is rapidly changing with the technical and commercial feasibility of battery storage providing grid-forming and system strength services actively being demonstrated (e.g. TransGrid's Wallgrove Grid Battery)
- We recommend NSW Government utilise this opportunity for access regime design to consider how renewables and storage can be optimally integrated in and around REZs and ensure a seamless (as well as cost-efficient) transition for all NSW consumers

Key Objectives	Battery storage benefits
Unlock additional Renewable Capacity with efficient network utilisation	With a wide range of energy, ancillary and system service applications, storage can accelerate new capacity faster than traditional network build, and provide planners with optionality benefits through modular, scalable projects
Expedite connection processes	Batteries, increasingly with grid-forming inverters, ensure system strength, voltage, and inertia contributions improve grid dynamics rather than negatively impact them – streamlining connection for renewables that may otherwise be considered 'harmful'
Improve investment certainty	Can address/negate curtailment, marginal loss-factor, or negative price risks and provide portfolio approach to maximise market revenues across and within REZs
Increase reliability	Time-shifting of energy ensures flexible dispatch de-coupled from the time of generation – ensuring peak and minimum demand can be managed securely
Improve affordability and market competition	Co-optimising energy and ancillary services, in addition to network and system services from the same asset lowers total expenditure and puts downwards pressure on wholesale and contract markets - lowering total consumer costs over the long-term
Support state's electricity roadmap and climate strategy	Unlocking additional renewables at scale, and providing essential system services previously only thought to come from thermal plants, accelerates the transition to a net-zero carbon future
Support regional economic development	Creates improved outcomes for communities – with order of magnitude greater construction and ongoing O&M jobs than syncons, and potential for innovation hubs, scaled build out in future as regional demands change over time

Multi-purpose battery storage systems are the 'Swiss army knife' of energy assets

- The role of storage is much broader than to mitigate thermal capacity congestion within a REZ. Battery energy storage can provide almost any grid service required, across a range of time scales
- From millisecond response - providing fast-responding ancillary services, through to generating over multiple hours - shifting energy production from off-peak to peak times and reducing the need for new peaking capacity – to addressing minimum operational demand issues by charging during high renewable output intervals
- 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 Appendix for additional detail)
- 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')
- Collectively, these services are of particular value in electrically remote and high-renewables penetrations regions such as REZs



For REZs, there are 3 key applications where batteries can competitively provide services

	Traditional Approach	Battery storage role
Capacity Constraints	Expand substation; network upgrade; curtail renewables **or apply access regime**	Defer/complement network investment, reduce risk of load shedding & congestion with 'virtual transmission'; improve MLFs
System Services	Syncons; Statcoms	Provide all inertia, system strength, voltage and network services via grid-forming battery inverters
Grid Protection & Resiliency	Network upgrade; synchronous plant back-up (diesel/gas generators)	Defer upgrades; contingency and re-start protection; resiliency services (SIPS, SRAS) – e.g. Victoria Big Battery

Using a single asset to provide energy, system and network services unlocks significant value

- Tesla's battery energy storage systems are technically capable of providing system strength services, as well as time-shifting renewable energy during periods of peak and negative demand to directly address constraints.
- Using battery storage assets for system strength can offset the need for synchronous condensers, reduce the risk of stranded assets in NSW, and reduce the overall network capital spend required for network infrastructure upgrades
- Whilst different commercial models can be applied for a shared network battery asset, the general benefits remain significant:
  - Cost recovery from renewable developers is lower as they are only covering costs of deploying one asset for multiple services
  - NSW Government overall funding contribution is lower as the need for syncons is redundant
  - TransGrid network investment is lower, while benefits are higher
  - As a result, customer bills are lower and community benefits greater
- If a REZ is congested, storage should not hampered by access rights to provide these critical system services, otherwise it would not create efficient market outcomes – counter to the national energy market objectives.

REZ Application	Battery Storage Benefits	Alternative Investment
System strength in regions of low system strength (fast acting voltage support)	• Improving voltage stability • Enables higher renewable penetration with Grid Following Inverters • Designing a greenfield REZ can be based on unit protection schemes that are not reliant on minimum fault levels for correct operation	Synchronous Condensers which are significant capex for specific and inflexible applications
Time shifting renewables • Reduced congestion / /curtailment of renewables • Improved MLF	• Market benefits • Relieving network congestion for future REZ via 'Virtual Transmission' concept • Improving revenue for renewable generators by improved Marginal Loss Factor (MLF)	More extensive transmission lines and substations to build out REZ
Deferring network constraints (RIT-T)	• Deferring long term network expansion investments (e.g. current TransGrid RIT-T consultation for Bathurst, Orange and Parkes areas)	Transmission lines and substations (potentially a less efficient capex solution for a particular network need)
Wholesale Energy / **FCAS** Regulation / FCAS Contingency	• Revenue stream for relevant market participant	New Generation
Inertia	• Reduced reliance on retiring synchronous machines	Synchronous machines

Technical Comparison: Synchronous Condenser vs grid-forming battery storage system

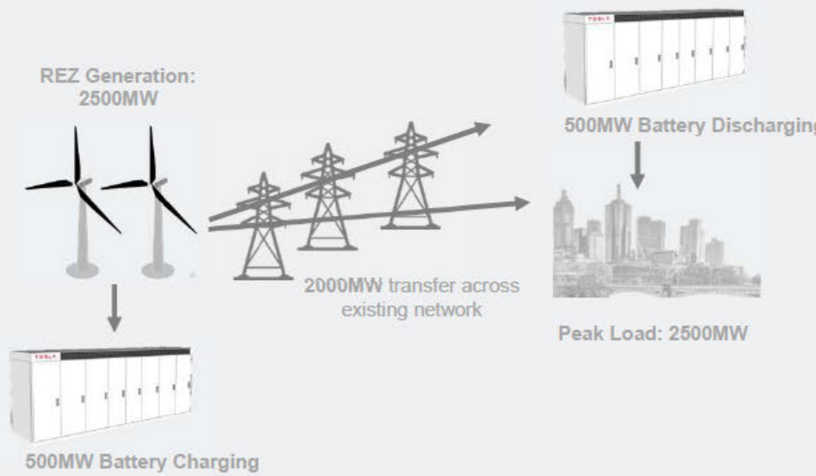
Feature	Tesla Inverter with Virtual Machine Mode	Synchronous Condenser
Inertia (frequency disturbance support)	Yes – configurable inertia response based on emulation of swing equation Response ime: < 0.5 cycles (10ms)	Yes – fixed inertial constant based on physical characteristics of the plant Response ime: Instantaneous
System strength (voltage disturbance support)	Yes – voltage smoothing (fast acting reactive power response)	Yes
Fault level contribution	Yes – up to 120% of inverter kVA rating for 10 seconds	Yes - substantial
Harmonic dampening	Active harmonic cancellation	Limited damping
Additional value services	All battery operating modes – enables value stacking	None

- Whilst relatively new to Australia's national electricity market, grid-forming battery storage systems are well-known and a long-proven technology globally, particularly in microgrid environments that are seeking to manage energy systems at 80-100% renewable energy penetration with solely renewable and storage assets
- Virtual Machine Mode is a 'grid-forming' feature implemented on Tesla inverters that mimics the behaviour of traditional rotating machines
- As shown in the comparison table, Tesla's systems can effectively match or outperform syncon functionality across key network features. In practice, this means Tesla Inverters operating in Virtual Machine Mode can provide inertia and fast acting voltage smoothing to support regions of low system strength
- 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 / 192 MWh and expand its suite of system support services through Virtual Machine Mode to include system strength, inertia services, voltage control and fast frequency response
- In addition, the Wallgrove Big Battery in NSW (supported by the NSW Emerging Energy fund) will apply Virtual Machine Mode to a 50MW Tesla battery for TransGrid to integrate system strength and virtual inertia services from battery storage into the NSW network

Network battery projects provide optionality ahead of full transmission expansions. This maximises efficiency of existing assets, and de-risks future expenditure

- The same battery storage assets providing immediate system strength services can de-risk long-term build out of REZs by providing flexible energy and ancillary services where it is needed most – benefitting multiple parties
- From a network planning and development perspective, this unlocks significant optionality benefits future investments are effectively brought forward and utilised for multiple purposes
- A key advantage of battery storage is its modularity and deployment flexibility. Following detailed design and network modelling, storage configurations can be scaled up or down depending on required applications to serve grid and market needs. For example, a 2-hour system for a dedicated REZ may be suitable for near-term system security, ahead of longer duration 4-hour options for system reliability benefits and during future network augmentation stages
- A pair of coordinated battery systems can also be deployed to orchestrate dispatch with each other and support the existing network by 'virtually' increasing transfer capacity during normal operation, and increasing supply reliability during peak demand
- Battery storage is also highly flexible in location – projects can be located at terminal substation or along existing network corridors, leading to smaller environmental footprints, no need for water/fuel/right of way etc. and ensuring additional community support and benefits

ILLUSTRATIVE EXAMPLE OF VIRTUAL TRANSMISSION LINES



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ii. CWO REZ Access Regime Design

Prioritisation of network investment (including storage) can address immediate connection and system strength constraints impacting renewables, alongside 'light touch' access reforms

- As highlighted throughout the AEMC's Coordination of Generation and Transmission Investment and ESB's REZ consultations, open access is not perceived to be the central problem or issue for renewable developers. Rather a lack of new transmission (slow and complex regulatory process preventing investment, and slow deployment speed once approved) is cited by the majority of stakeholders as the key problem to solve. Related to this, issues causing most alarm to investors are system strength constraints and slow and expensive connection processes
- Accelerated network investment under NSW's Efficiency Test, including deployment of grid-forming battery storage to address system strength, alongside market reforms (e.g. TransGrid's system strength rule change) can solve these priority issues. This also addresses the 'chicken and egg' issue, with NSW Government effectively supporting TransGrid to build out the network alongside committed generation under light touch access requirements (e.g. bid bonds or entry fees for first movers) that only apply to wind and solar - in return for REZ benefits (MLF stability, streamlined connection, access to shared storage etc.)
- In contrast, if designed poorly or if too complex, attempts to restrict access can result in transmission under-utilisation, dampen investment in storage, and create asymmetries across REZs and states (pending Victorian and ESB processes). A major benefit of the NEM is its uniformity of rules and administrative arrangements
- Once transmission and central REZ storage is planned and committed, connecting generators can apply for access under limited adaptation of the current regime (e.g. first mover bids/payments in return for access rights and REZ incentives). Given constraints are a risk that will always exist on the shared network irrespective of the REZ access regime, consideration of additional projects to join the REZ should be given, as this forces competition on price to be dispatched (good for consumers), but is unl kely to add substantial investment risk – provided there is improved transparency and information sharing
- Further, if the REZ network capacity is sized appropriately, this becomes largely a theoretical issue - given land and access to network (i.e. attractiveness of PPAs) and threat of declining MLFs reducing the commercial viability of incremental projects (and increasing only their individual capital cost). This approach also promotes competition for lowest generation to avoid 'lock-in' of high cost plant – e.g. if innovations in solar panels, wind turbine or battery technologies can outcompete existing technologies in 20 years, this should be encouraged

Option 0	Accelerated Network Build with 'Light-touch' Access Regime (exempting storage)
Option 1	Limited Physical Connection
Option 2A	Financial Compensation – Static Access
Option 2B	Financial Compensation – Dynamic Access

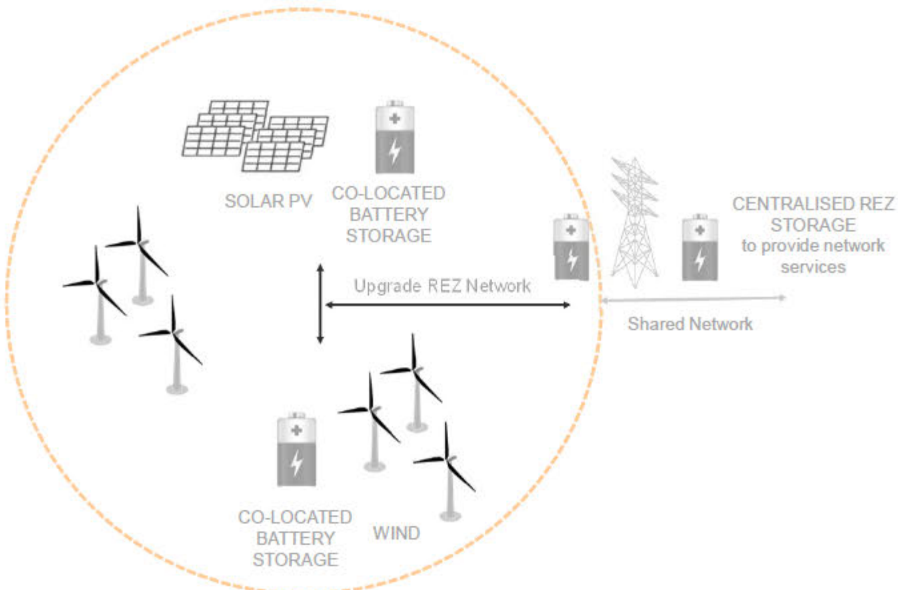
CWO REZ Options Assessment

Option 0 – Accelerated build out of REZ & shared network assets, with light touch access regime (that excludes storage)

- The access options analysis should consider the simplest option at commencement of CWO REZ: accelerated transmission investment, with greater information sharing and coordination, and only a minor adaptation of the current open access regime (e.g. bid bonds for first-movers)
- Focus on no-regrets acceleration of NSW's New Efficiency Test for transmission (alongside Actionable ISP framework) and working with generators, communities and consumer groups to ensure fast but considered build out of TransGrid network to maximise utilisation
  - As TransGrid notes: *"currently limited to no capacity on the existing 132kV and 330kV elements of the network in or near the areas of NSW that have good wind and solar resources. Increasing the capacity of the transmission network, including REZs, through the actionable ISP rules framework will resolve many of the issues currently being faced in the NEM. Broader access reform may be a useful complement to the actioning of the ISP in the longer term"*
- To support efficient network build, and satisfy legislative requirements, NSW can explore mechanism such as non-refundable bid-bonds that provide initial REZ exclusivity, which will also provide certainty for sufficient generators to locate and ensure optimal utilisation of the network
- The optionality and benefits provided by storage as a virtual transmission asset and to streamline connection requirements can also be leveraged to avoid over-capitalization in the short term

RISK TO STORAGE

- Expenditure focuses on traditional 'poles and wires' and syncons due to familiarity. Strongly recommend NSW New Efficiency Test requires both network and non-network option assessment – to allow virtual transmission and technology innovations to compete with traditional solutions
- May still require additional locational incentives – i.e. exploiting economies of scale / streamlined connections / MLF uplifts could be a sufficient 'carrot' to locate in REZ



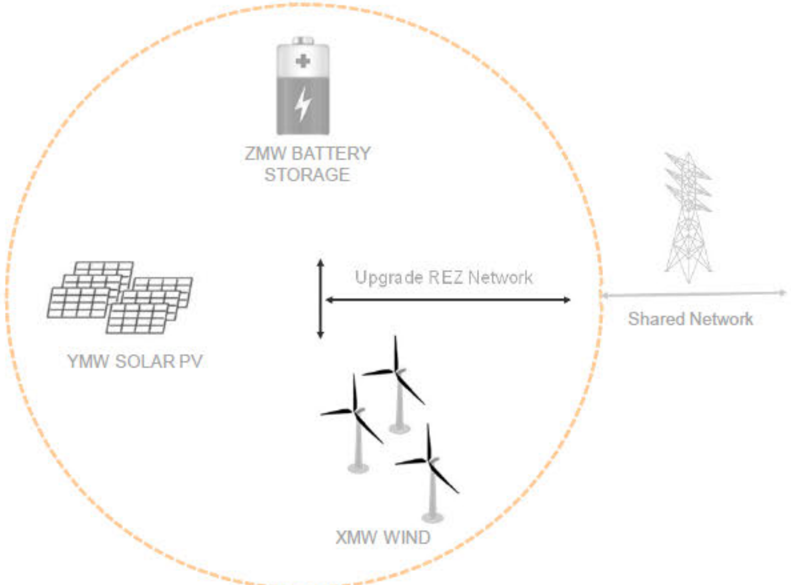
REZ – Option 0
New Transmission Build with access exemptions for Storage

Option 1 (Limited Physical Connection) would need to overcome the challenges of centrally planning optimal capacity mix, and may need to evolve over time

- XMW Wind, YMW Solar and ZMW of stand-alone storage per REZ allocated access rights to ensure efficient utilisation of network capacity (with some, but minimal constraints)
- Storage should be excluded from access right allocation, but if included, the scheme must recognise 'non-energy' value of storage services – e.g. system strength, inertia, voltage stability – as non-energy constraints may actually drive more of the grid access across the REZ over time
- Co-located storage should also not be counted under a project's cap - i.e. existing wind/solar projects should not be prevented from adding storage and forming a hybrid system – as this firmed energy would provide additional benefit to the grid and unlock additional REZ capacity
- Alternative option could be to not restrict based on optimal technology mix, instead accept capacity based on time of day – i.e. solar plus storage could bid for night-time capacity allocations alongside wind. But this may further limit opportunities for storage as there would not be a headline storage target per REZ – and would rely more on centralised storage deployment via NSW Energy Co

RISK TO STORAGE:

- Storage capacity should not be included in a cap – this fails to recognise essential system services
- Securing access rights can negatively influence business case for storage
- Individual wind/solar projects may have less incentive to install co-located storage to firm generation – as access rights guaranteed within REZ (less need to time-shift to non-peak periods) but may still see value in accessing a shared/centralised storage system for market revenue uplift and hedging
- If co-located storage is counted in wind/solar cap, makes it harder or potentially locks out access and optionality for hybrid systems if individual proponents still want to develop
- Hard to justify additional mechanisms to incentivise storage to charge during times of congestion – as there should be limited congestion

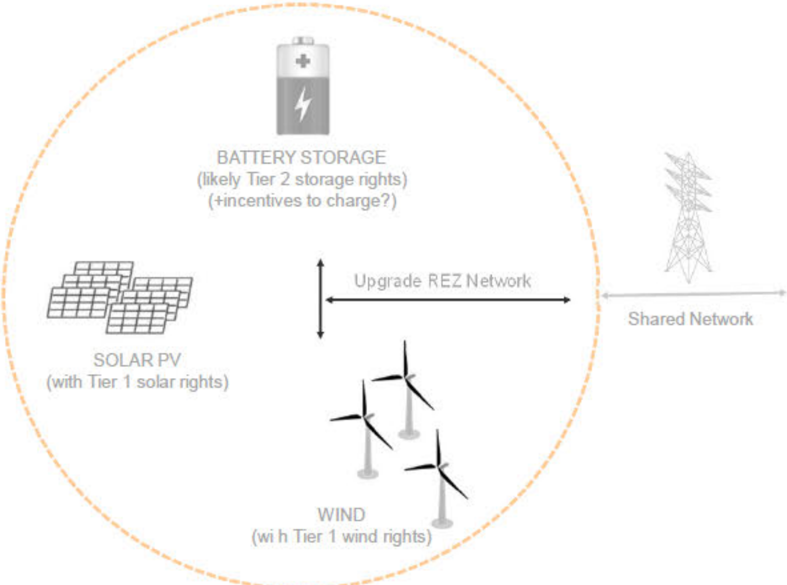


REZ – Option 1
Limited Physical Connection

Option 2 is a more efficient regime. But trade-off in complexity. And specific mechanism for developer-led storage may still be required to incentivise REZ location

CONSIDERATIONS AND RISKS FOR STORAGE:

- What is the incentive for stand-alone storage to purchase rights and locate within the REZ? vs locating on the share network and avoiding: (a) risk of paying financial compensation; (b) cost of purchasing access rights; and (c) having reduced operational flexibility?
- How will additional services from storage be valued? (e.g. FFR, system strength, inertia etc.)
- Requiring stand-alone storage to purchase access rights can undermine entire business case for battery storage. The scheme needs to provide benefits/savings greater than the costs of paying for access (otherwise why locate in REZ?)
- Option 2B appears to completely remove incentives to co-locate (or purchase virtual) storage – since solar projects would only have midday access rights sized at nameplate capacity
- It is unclear what storage access rights would look l ke - e.g. 2 and 4 hour blocks during peak time?
- If storage rights are allocated in time blocks – this can limit flexibility of storage to optimise and provide most valuable services when required
  - e.g. contingency event at midday, but storage only has access rights from 5pm to 9pm, is storage financially restricted / penalised from supporting grid?
  - This would disincentivise storage from locating within the REZ – as there is any asymmetry in revenue opportunities – very few intervals produce most of the annual revenue
- Investors will not finance storage if it is at risk of receiving no revenue during high price periods. Note that outcomes are asymmetric – less value in lowering charge costs from $10 to $0/MWh (or less), but preventing access to $15,000/MWh price spikes can significantly hamper business case
- Additional incentives to encourage storage to charge during congestion periods may be required, but should recognise increasing prevalence of $0/MWh and negative price events
  - i.e. if BESS inside REZ is offered $0MWh charge rate during congestion, BESS outside REZ may actually access -$1000/MWh pricing



REZ – Option 2B
Enhanced Financial Compensation

TESLA

Appendix: Battery services to support REZ development

Constellation of System Services from Tesla's battery storage technology

System Service provision - comparison across assets / technologies:

Asset / Service	Tesla battery (with Virtual Machine Mode)	Synchronous Generator	Variable Renewable Generator	Static VAR Compensator (SVC)	Synchronous Condenser (Syncon)	Static Synchronous Compensator (STATCOM)
Inertia	✓	✓	✓*		✓	✓
Voltage stability	✓	✓	✓	✓	✓	✓
System strength	✓	✓			✓	
Harmonic dampening	✓			✓	✓	✓
Frequency Stability	✓	✓	✓			
Fast Frequency Response	✓		✓*			
Stand-alone / system re-start services	✓	✓				

✓ Some / minimal functionality – e.g. *some new wind farms with appropriate control systems

✓ Standard functionality

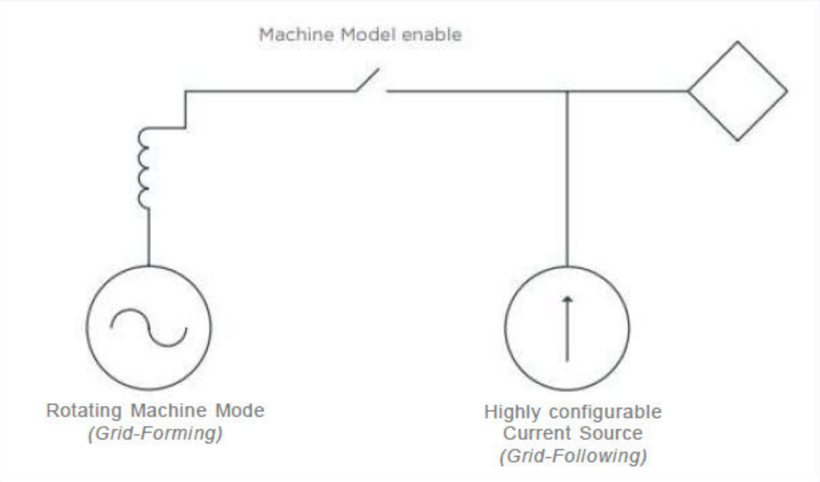
✓ with Tesla Virtual Machine Mode (grid-forming)

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 control over the degree 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

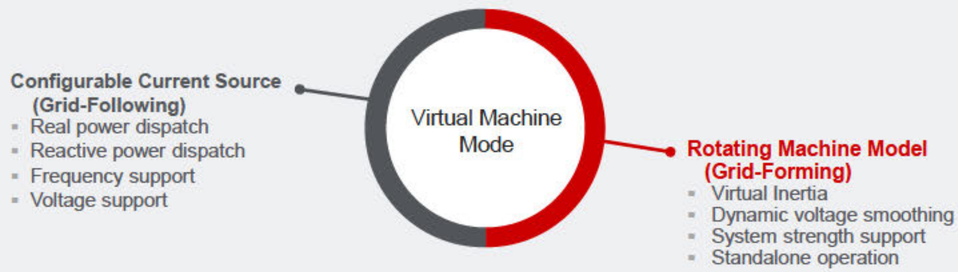
Tesla – Virtual Machine Mode

Inverter based system strength and virtual inertia

- Tesla Inverters operating in Virtual Machine Mode can provide inertia and fast acting voltage smoothing to support 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).
- 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. The inertia constant of a Tesla battery can be configured from 0.1 to 20MW.s/MVA.
- In addition, inverter based technologies can utilise 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.



Case Study: Virtual Machine Mode

Hornsdale Power Reserve Expansion

- 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 / 192 MWh – maintaining its crown as Australia's largest battery while expanding its suite of system support services.
- Hornsdale will be the first battery in the NEM to operate in Virtual Machine Mode, proving its capability as a provider of system strength, inertia services, voltage control and fast frequency response.
- Through this trial, Tesla intends to have storage recognised by AEMO as having a positive, rather than a neutral contribution to system strength.
- Once expanded, the Hornsdale Power Reserve could provide up to 3,000MWs of inertia to the local South Australian grid.