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Dynamic battery reserves can deliver network benefits

Maximising renewable generation and improving electricity network utilisation with a *"Flexible BESS-SIPS Portfolio"*

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Key Findings

Transmission lines are often run well below capacity so the network can cope if a fault occurs. This increasingly limits renewable energy flows.

Single batteries already help transmission lines carry more power. The Victorian Big Battery and Waratah Super Battery do this under SIPS contracts, with the Waratah contract now more flexible to improve utilisation.

A Flexible BESS–SIPS Portfolio could extend this service so that multiple batteries could be enabled to support transmission lines to run at higher levels, unlocking more renewable energy from REZs.

The concept should be tested through modelling and a trial, and optimal procurement routes identified. A new System Operator function should be established to co-ordinate the Flexible BESS–SIPS Portfolio.



Executive summary

As Australia's National Electricity Market (NEM) transitions to low-carbon energy resources, previous forecasts of low demand growth are being replaced by an increase in demand due to an uptake in consumer electrification and data centre connections. While new generation and load connections typically have delivery timeframes of two to three years, transmission projects have much longer delivery timeframes. The sequencing gap between connections and transmission development increases the risk of energy supply limitations and high electricity prices arising from insufficient transmission capacity.

The low-cost renewable power that can flow from Renewable Energy Zones (REZs) can be limited not only by what the lines can physically carry (based on thermal ratings), but also by the level of power flow that can be safely managed if something goes wrong (i.e. a contingency event occurs). To manage contingencies after they happen, post-contingency reserves are often required. In this report, "reserve" means capacity held on standby so it can rapidly inject or absorb power after a network fault, and to help return the network to a secure state (rather than system-wide reliability reserves such as the Reliability and Emergency Reserve Trader or RERT).

At present, a network or system operator may have a contract in place with a single battery energy storage system (BESS) to provide a rapid response to an event as part of a System Integrity Protection Scheme (SIPS). Such an arrangement enables increased pre-event power transfer on a single transmission corridor (or in some cases, such as the Waratah Super Battery, multiple corridors). These arrangements have been evolving, with more flexibility added to the Waratah Super Battery SIPS contract so the service is only activated when needed (with at least 24 hours' notice), leaving the battery free to trade at other times.

This report builds on that evolution, introducing the high-level concept of extending the SIPS to procure additional reserves, in a flexible manner, from multiple BESS facilities (rather than just one), to increase power transfer on multiple transmission corridors. We call this a "Flexible BESS–SIPS Portfolio".

A new System Operator function could be established to identify when additional reserves are required, particularly during periods of high REZ generation, high demand or planned outages, and optimise the quantity and type of reserve response from any participating BESS. This function would support greater utilisation of existing transmission infrastructure and facilitate higher levels of renewable energy transfer.

Unlike traditional SIPS arrangements, which reserve battery capacity to respond on an ongoing basis, BESS capacity would only be enabled when needed, allowing any participating BESS to continue operating in energy markets at other times.

Depending on the transmission corridor, battery capacity enabled for rapid response, slower resecuring response, or a combination of both may be required to increase power transfer and

network utilisation. The System Operator would optimise the mix of rapid response (within 200 milliseconds) and slower resecuring response (within 30 minutes) to manage system security and operational risks while making efficient use of both transmission and battery capacity.

A Flexible BESS–SIPS Portfolio could theoretically deliver the following benefits:

- Increase REZ generator export and reduce curtailment of renewable energy, thus placing downward pressure on wholesale energy prices.
- Improve network utilisation, reliability and the co-ordination of generator response.
- Support the connection of large loads, and avoid load tripping.

Recommendations

This report recommends further technical assessment to confirm technical feasibility, economic viability, locational requirements for participating BESS, the potential uplift in transfer capacity, and the need for any network reconfiguration to support higher power transfer.

The Australian Energy Market Commission (AEMC) should consider the benefits of standalone BESS and hybrid systems delivering a Flexible BESS–SIPS Portfolio response to increase network capacity as part of its Electricity Network Regulation Review.

Market analysis is required to determine the appropriate mechanism to facilitate procurement of an optimised Flexible BESS–SIPS Portfolio. In the short term, it could be procured through existing non-market routes, such as government tenders, a Transmission Network Service Provider (TNSP) network support agreement, a Network Support and Control Ancillary Services (NSCAS) contract, or a Type 1 or Type 2 Transitional Services contract. In the longer term, a dedicated rule change request could explore the benefits of establishing a new mechanism.

A system trial should be undertaken to capture the number and duration of periods when a Flexible BESS–SIPS Portfolio (providing rapid response and/or slower resecuring response) would be required, the available battery capacity and the potential uplift in capacity to confirm indicative cost per megawatt ($/MW) benefit.

Introduction

The difference between construction times for renewable generation, battery energy storage system (BESS) and load projects (typically two to three years based on transformer lead times[1]), and the delivery of new transmission line capacity (up to eight years) presents a risk of future energy supply limitations. This could flow through to high electricity prices arising from insufficient transmission capacity, particularly if major infrastructure projects are delayed.

Increased investment in renewable generation, the need to charge remote battery systems, and the growth of consumer and data centre demand will push the existing transmission network towards design and/or operational limits. This will be particularly apparent at times of high renewable output and/or high demand.

Firmed capacity: The subject of recent commentary, this is generally considered to be where a BESS is either paired with a renewable energy source to provide dispatchable energy supply, or where the BESS is co-located with a load to offset the peak net demand.[2] While these hybrid connection arrangements can manage the risk associated with generator or load curtailment, they do not address the network issue of insufficient transmission capacity. These forms of firmed capacity are available for a finite time; once the BESS is fully discharged, supply restrictions return, with little energy or reserve available. This report describes how BESS enabled to provide reserve can contribute to **firmed *transmission* capacity** by enabling increased export from Renewable Energy Zones (REZs).

Current approach: At times of high demand and/or high renewable generation export, system constraints ensure secure network operation. Where available, generation runback schemes, load-tripping schemes and single BESS–SIPS schemes are enabled to maximise transfer while managing network loading after a specific network event. If a post-event load-tripping or special protection scheme cannot be designed to manage the post-event network operating condition, generation can be constrained and/or the demand on the network is reduced or disconnected pre-emptively. Maximum power transfer on high-capacity lines could also be limited due to available resecuring reserve; current SIPS schemes do not address this operational limitation.

Proposed approach: Enabling a flexible portfolio of BESS with the ability to provide a post-event SIPS response (rapid response and/or slower resecuring response) can:

a) Allow increased power transfer from REZs to metropolitan load centres.
b) Allow battery systems to gain access to flexible charging capacity.
c) Manage risks associated with loss of large load or generation facilities.

[1] Switchyard supply. Why LPT and GSU lead times run measured in years.
[2] Also referred to as “firmed renewable supply” or “firmed renewable generation capacity”.

These benefits would be realised not only under normal operating conditions but also during planned outages, when lines are taken out of service for maintenance.

Background

The National Electricity Market (NEM) operates through a suite of real-time markets, the spot energy market and the co-optimised Frequency Control Ancillary Service (FCAS) markets, which keep supply, demand and frequency in balance. These markets are designed for services that can be bid competitively, standardised and dispatched through the NEM Dispatch Engine (NEMDE). Alongside these markets sit network services such as system strength and inertia, traditionally supplied as a byproduct of synchronous generators, and increasingly procured by Transmission Network Service Providers (TNSPs). However, not all security needs can be met through markets or network assets. This is where Non-Market Ancillary Services (NMAS) play a critical role. These include:

- Network Support and Control Ancillary Services (NSCAS).
- System Restart Ancillary Services (SRAS).
- Transitional Services.

NMAS allows the Australian Energy Market Operator (AEMO) to contract bespoke or emerging security services that cannot be provided efficiently through markets, including restart capability, network support, Minimum System Load (MSL) support, synthetic inertia and grid-forming trials. Additional non-market mechanisms such as Reliability and Emergency Reserve Trader (RERT) and SIPS provide reserve and fast-stability support when reliability or system security are at risk. Together, these mechanisms form a layered security framework that complements the energy and FCAS markets.

Note, there is no market for “resecuring reserve”, the capability required to restore secure operating conditions after major disturbances. AEMO relies on available reserve within the energy market that is not dispatched, managed through the Lack of Reserve (LOR) framework, rather than on dedicated, contracted services.

A summary of the market and non-market services that operate within the NEM is provided in the Appendix, highlighting how each contributes to system reliability and security. A summary of key relevant Service Types is provided below.

Regulation and Contingency FCAS: Regulation FCAS maintains frequency close to 50 Hertz (Hz) during normal operation through continuous automatic generation-controlled (AGC) balancing. Contingency FCAS responds to sudden disturbances, and is procured across three timeframes: Fast (6 seconds), Slow (60 seconds) and Delayed (5 minutes). As the grid’s synchronous inertia declines, a faster service Fast Frequency Response (FFR), has emerged to arrest rapid frequency changes within one to two seconds, providing critical stability support.

NSCAS: Non-market services procured to address specific network limitations such as voltage control, stability constraints, or transfer capability issues that cannot be resolved through transmission assets alone. They provide targeted support to maintain secure network operation, and ensure power system stability under conditions where market-based services are insufficient.

Transitional Services: Non-market ancillary services that allow AEMO to procure emerging or innovative security capabilities that are not yet available through existing markets or network frameworks. They provide targeted support for evolving system needs, such as minimum system load management, synthetic inertia, or grid-forming behaviour, enabling secure operation during the transition to high levels of inverter-based resources.

RERT: Procures out-of-market reserve ahead of time (up to one year) when AEMO forecasts insufficient reserves to meet the Reliability Standard. It provides emergency capacity that can be dispatched or activated during periods of extreme tightness to avoid involuntary load shedding.

SIPS: A protection scheme that automatically acts after defined faults, for example by tripping generation, and injecting battery power within 200–300 milliseconds (ms), to keep the network within safe limits, and allow higher power transfer limits.

Operating reserves: Generation or storage capacity that can be rapidly called on to manage unexpected changes in supply or demand, providing a slower but essential stabilising response compared with contingency FCAS. Historically, these reserves were implicitly available "for free" by partially loaded synchronous generators; as synchronous plant retires, this inherent headroom, and the implicit reserve it provided, is disappearing.

There is no dedicated market for operating reserves. Instead, AEMO relies on undispatched capacity in the energy market, and monitors and manages reserve levels through a suite of operational mechanisms, including pre-dispatch, PASA (Projected Assessment of System Adequacy), LOR notices, RERT and, when necessary, Directions, to ensure the power system remains reliable under changing conditions.[3]

AEMC Operating Reserve Review

Between 2020 and 2024, the Australian Energy Market Commission (AEMC) undertook an extensive, multi-stage assessment of whether the NEM required a new operating reserve market to manage rising variability, uncertainty and declining system resilience as variable renewable energy (VRE) penetration increased.[4,5,6,7] The process was initiated by rule change requests from Infigen[8]

[3] Australian Energy Market Commission (AEMC). National Energy Rules. Power to issue directions and clause 4.8.9 instructions.
[4] AEMC. System Services rule changes. 2 July 2020.
[5] AEMC. Consultation Paper: System Services rule changes. 2 July 2020. Pages 38–40.
[6] AEMC. Directions Paper: Reserve Services in the National Energy Market. 5 January 2021. Pages 20–34.
[7] AEMC. Directions Paper: National Electricity Amendment (Operating Reserve Market Directions Paper) Rule. 3 August 2023. Pages 21–28.
[8] Infigen. Re: Operating Reserves and Fast Frequency Response Rule Change. 18 March 2020. Pages 4–8.

(operating reserves) and Delta Electricity[9] (ramping services), and was informed by AEMO's technical advice, stakeholder submissions and broader system security reforms.[10,11,12,13,14,]

AEMO's analysis highlighted worsening forecast error, especially rooftop solar PV error, increasing ramping events, and a growing disconnect between low reserves and low spot prices, which meant scarcity was not always signaled to the market. AEMO warned that, without stronger incentives, it may need to intervene more frequently using RERT. AEMO therefore supported consideration of an operating reserve product with one- to four-hour timeframes.

However, AEMC modelling suggested that the future fleet, characterised by high levels of storage and flexible plant, would be capable of managing variability without introducing a new reserve market. Stakeholder feedback to the 2023 Directions Paper and Draft Determination was "near unanimous"[15] in agreeing that an operating reserve market would not materially improve reliability, and would impose significant additional cost.

A major contribution during the consultation came from Powerlink, which indicated that existing FCAS and reserve arrangements constrain the size and efficiency of REZs connected via double-circuit transmission lines.[16] Under current rules, REZ generation must run back to the emergency rating of the remaining circuit following a line trip, and then further reduce output to align with the largest credible contingency (up to 750MW, based on the size of the Kogan Creek generator system). Powerlink proposed subregional FCAS and/or operating reserve procurement to allow higher REZ generation levels, improve utilisation of transmission infrastructure, decrease the number of REZs required, reduce connection costs and minimise community impacts. Powerlink emphasised that more localised FCAS and reserve procurement could enable scale-efficient REZ development, accelerate the energy transition, and reduce overall system costs.

The AEMC acknowledged the potential value of Powerlink's subregional FCAS/operating reserve proposal but determined it should be assessed through a separate, dedicated rule change process, not within the operating reserve review. This report builds on that pathway.

System Integrity Protection Schemes (SIPS)

In the absence of a subregional (localised) market for FCAS or reserves, TNSPs have entered into contract agreements with battery owners to hold capacity in reserve for SIPS response to enable

[9] Delta Electricity. RE: Capacity Commitment and New 30-minute FCAS Raise and Lower NEM Rule Change. 4 June 2020. Pages 1–4.
[10] AEMO. Submission to the AEMC's Consultation Paper – System Services Rule Changes. 13 August 2020. Pages 10–12.
[11] AEMO. Submission to the AEMC's Directions Paper – Reserve Products in the NEM. 11 February 2021. Pages 1–4.
[12] AEMO. Request for advice on design elements, cost and timing of operating reserve market. 8 February 2022.
[13] AEMO. Operating Reserve Design. November 2022. Pages 1–12.
[14] AEMO. Operating reserve market – Directions Paper. 31 August 2023. Pages 1–8.
[15] AEMC. Rule determination: National Electricity Amendment (Enhancing reserve information final determination) Rule 2024. 21 March 2024. Page 16.
[16] Powerlink. Development of Regional/Subregional FCAS and/or Operating Reserve Markets. 20 June 2023. Pages 1–5.

increased power transfer on specific transmission corridors. Examples include the Victorian Big Battery (VBB) to increase flows on the Victoria to New South Wales Interconnector (VNI), and the Waratah Super Battery (WSB) to increase flows to the Sydney–Newcastle–Wollongong (SNW) region from the north and the south.

The Victorian Big Battery (VBB)

The Victorian Big Battery (300MW) is contracted by AEMO under the Victorian government's "Vicxit" framework to provide a specialised SIPS service.[17] The Ministerial Orders define the non-network service as, "a System Integrity Protection Scheme thermal service capable of delivering up to 250MW of continuous power generation for a period of at least 30 minutes to increase the transfer capacity of the VNI".[18]

The battery's contracted capability effectively provides additional headroom of up to 250MW on these thermal overload limits, enabling higher imports under some conditions from NSW on top of flows from hydro generators in north-east Victoria and the Snowy scheme.[19]

AEMO has agreed to pay the battery owner AU$12.5 million a year (adjusted for inflation) for providing the contracted 250MW SIPS service during the four-month summer operating window from 1 November to 31 March, from 1 November 2021 to 31 March 2032.[20] Contracting a fixed quantity of capacity, regardless of system conditions or whether the full uplift in transmission capacity is achieved, introduces a risk that the battery could be underutilised.

The Waratah Super Battery (WSB)

The Waratah Super Battery, physically rated at 850MW/1,680MWh, is contracted to provide 700MW of guaranteed active power under a 5½-year SIPS agreement between Transgrid and Akaysha Energy. Under the SIPS framework, the WSB enables transmission lines into Sydney, Newcastle and Wollongong to operate at higher transfer limits by rapidly responding to faults. The contract also includes paired generation services from the Metz Solar Farm, Sapphire Wind Farm and Snowy Hydro's Tumut 3 pumped-hydro station, ensuring the SIPS can deliver 700MW when required and smaller "sculpted" amounts at other times. While Akaysha Energy can operate the battery in the wholesale market, the SIPS contract is expected to provide the majority of short-term revenue, reflecting the battery's central role in NSW's reliability and transmission-support strategy.[21,22,23] Use of the battery to increase flow on two transmission corridors improves battery utilisation, although it

[17] Energy Networks Australia. Transmission troubles: will Vicxit fix-it? 20 February 2020.
[18] Victorian government. Victorian Government Gazette: VNI SIPS Ministerial Order. 15 May 2020. Page 4.
[19] Australian Energy Council. Victoria's Big Battery: What exactly is it for? 26 November 2020.
[20] Ibid.
[21] Australian Energy Regulator. Waratah Super Battery – SIPS battery service. 14 December 2022.
[22] EnergyCo. Waratah Super Battery Project begins partial operation as shock absorber for NSW grid. 25 August 2025.
[23] Renew Economy. Massive and unprecedented injection of power as Super Battery tests its full shock-absorber capacity. 9 September 2026.

is not known the extent to which available battery capacity and power transfer is co-optimised, and how the contract cost aligns with usage. More flexibility has since been added to the WSB contract so the SIPS service is only activated when needed (with at least 24 hours' notice), leaving the battery free to trade at other times.[24]

Transitional services

Transitional contracts (transitional services) in the AEMO framework are a new class of power–system–security services AEMO can procure under National Energy Rule (NER) 3.11.11, introduced in March 2024.[25] They sit between traditional ancillary services and emerging security needs in a high-inverter-based resource (IBR), low-inertia system.

Transitional services are defined in NER Chapter 10 as services provided by plant, equipment or facilities to meet a power system security need arising from the energy transition. They are explicitly intended to bridge gaps until enduring market or regulatory frameworks exist.

AEMO's Transitional Services Guideline defines two categories:[26]

- Type 1 — Services that directly address an identified security need (e.g., minimum system load support, fast frequency response from non-market providers).
- Type 2 — Services that trial new technologies or new applications of existing technologies.

Both types may be procured for Minimum System Load (MSL) conditions, system strength support or other emerging security gaps.

Proposed solution: Flexible BESS–SIPS Portfolio

The proposed solution outlined in this report is a "Flexible BESS–SIPS Portfolio": an extension of current SIPS arrangements to include multiple batteries, supporting multiple transmission corridors, used in a flexible manner. The Flexible BESS–SIPS Portfolio would hold battery capacity in reserve to provide a rapid automatic response to a fault (within 200–300ms) and/or a slower resecuring response dispatched by the system operator within 30 minutes. This would be a subregional (local) response focused on freeing up transmission lines to run at higher levels. The responses of the portfolio of BESS systems would be co-ordinated with subregional runback schemes.

This solution is ideally placed to allow maximum export from REZs. Maximum power transfer across transmission line circuits is determined by system operating standards, which ensure that when an

[24] Renew Economy. Australia's most powerful battery set free of massive "shock absorber" contract after delay to Eraring coal closure. 10 October 2026.
[25] AEMC. Improving Security Frameworks for the Energy Transition. 28 March 2024.
[26] AEMO. Transitional Services Guideline. 8 November 2024. Pages 5–6.

asset is subject to a fault and trips, design limitations are not exceeded and the network remains stable.

Immediately following a fault and trip of a transmission line, power flow is redistributed across the remaining transmission lines. The system is operated in a “secure operating state” such that in the event of the loss of a network asset, the network remains in a “satisfactory operating state”. This indicates the power flows on the remaining assets are within design ratings (i.e. short-term ratings), and network voltage remains within an acceptable range.

Following a network fault event and asset trip, the system operator has 30 minutes to return the network to a “secure operating state” to ensure the network will remain stable following a further fault event. This is referred to as “resecuring” the network, and may involve the redispatch of generator systems.

One of the criteria for a secure operating state is that the largest contingent risk of loss of load or generation should not exceed a value specified by the associated transmission system planner. In Victoria, the largest permissible loss of load associated with a single fault event is 600MW, while the largest permissible loss of generation associated with a single fault event is 750MW.[27] FCAS is procured to manage the loss of a load or generation, to ensure system frequency remains within allowable limits.

At present, individual BESS systems have been contracted to respond to a specific fault event to ensure power flows on remaining assets can be quickly reduced to within short-term ratings following the loss of a transmission asset. This is executed by the trip of generation systems upstream of the fault, while a single BESS downstream of the fault quickly discharges. The response time is typically less than 300ms with asset loading being within acceptable levels for this very short interval. The network loading for the subsequent five minutes is within acceptable five-minute ratings until the system is redispatched via the NEM dispatch engine (NEMDE).

It should be noted that a BESS–SIPS response can be contracted to provide sustained output for up to 30 minutes, to allow time for generation redispatch. Once generation is redispatched, the responding BESS can be returned to its pre-event SIPS-enabled status, subject to network conditions and contractual agreement.

The proposed approach is to enable an optimised, co-ordinated, post-event response from a portfolio of available BESS that allows increased utilisation of multiple high-capacity, high-voltage transmission lines. Enabling a post-event response will allow increased power transfer from REZs when all assets are in service, and ensure system security following the loss (outage) of a transmission asset.

[27] AEMO. 2025 Victorian Annual Planning Report. October 2025. Page 83.

Furthermore, multiple BESS can act to reduce the potential maximum loss of load or generation associated with a single network event to allow increased power transfer or increased levels of load or generator MW connected via a single transmission asset.

In recent years, the potential for BESS systems operating as "virtual transmission" has been introduced as an option to overcome transmission constraints. This report reframes the virtual transmission concept as a **System Operator function**, which, when enabled, could provide increased transmission capacity at times of high network loading.

Unlike the NEM-wide operating reserve market, which the AEMC assessed and declined in 2024, this report proposes corridor-specific, BESS–SIPS procurement, consistent with the pathway the AEMC left open for further consideration through a dedicated rule change process.

Powerlink proposed subregional FCAS and/or operating reserve markets, drawing on any technology, to lift the limit on resecuring the network after a fault. However, a Flexible BESS–SIPS Portfolio would use co-ordinated batteries, which could be procured initially through existing contract routes, to provide both a rapid response that lets lines carry more power before a fault, and a slower response to help resecure the network afterwards. Unlike the single network battery, which Powerlink rejected on cost grounds, the portfolio would draw on a number of market batteries placed on standby only when needed.[28]

The following sections present operating scenarios that demonstrate how the enablement of a portfolio of BESS:

- Enables increased dispatch from REZs.
- Manages power system reliability during planned outages.
- Enables load connection and battery charging.

Enabling increased dispatch from REZs

The following examples demonstrate how storage systems can enable increased power transfer of low-cost energy from a REZ via 330 kilovolt (kV) and 500kV transmission assets. The examples are conceptual in nature, and show scenarios where rapid response is required, and where a combination of fast and slower resecuring response is required, demonstrating the need for flexible dispatch options. For ease of describing and understanding the high-level concept, network losses and the transfer of reactive power have been ignored. Thermal ratings and power flow are referred to as active power values (MW) rather than apparent power (megavolt–amperes, MVA). The examples assume a 15-minute overload rating equal to 110% of continuous rating is achievable on high-voltage transmission lines (reasonable assumptions based on power system modelling

[28] Powerlink. Development of Regional/Subregional FCAS and/or Operating Reserve Markets. 20 June 2023. Page 4.

experience). The largest permissible loss of generation associated with a single fault event is assumed to be 750MW.

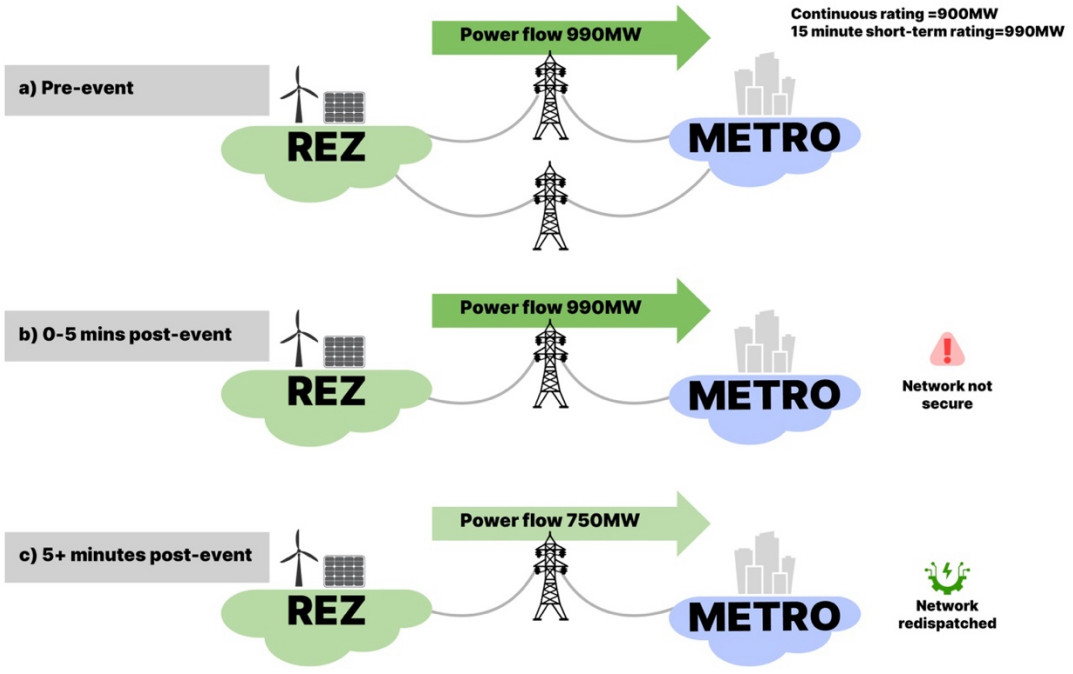
Example 1. 330kV double-circuit transmission

Without Flexible BESS–SIPS Portfolio: Design standards for a 330kV high-voltage, double-circuit transmission line determine that the power transfer is limited to the post-event rating of one of the two parallel circuits. When considering two circuits, each rated at 900MW (continuous), 990MW (15 minutes, short term), the maximum power transfer from the REZ is limited to 990MW, based on available capacity when one of the two lines is lost (referred to as N–1 capacity). Essentially, this results in each circuit, prior to the event, being loaded at 55% of maximum rated capacity, to ensure the remaining circuit is not overloaded following the loss of one circuit.

The largest permissible loss of generation associated with a single fault event is 750MW. Following the loss of a line, the remaining line transfers 990MW. As this power flow is greater than the permissible single largest loss of generation, the generation will be redispatched within 30 minutes to reduce the power flow on the remaining line to 750MW.

The pre- and post-event power transfer for the 330kV double-circuit example without a Flexible BESS–SIPS Portfolio is illustrated in Figure 1.

Figure 1: 330kV double-circuit transmission line *without* Flexible BESS–SIPS Portfolio



Source: Author analysis

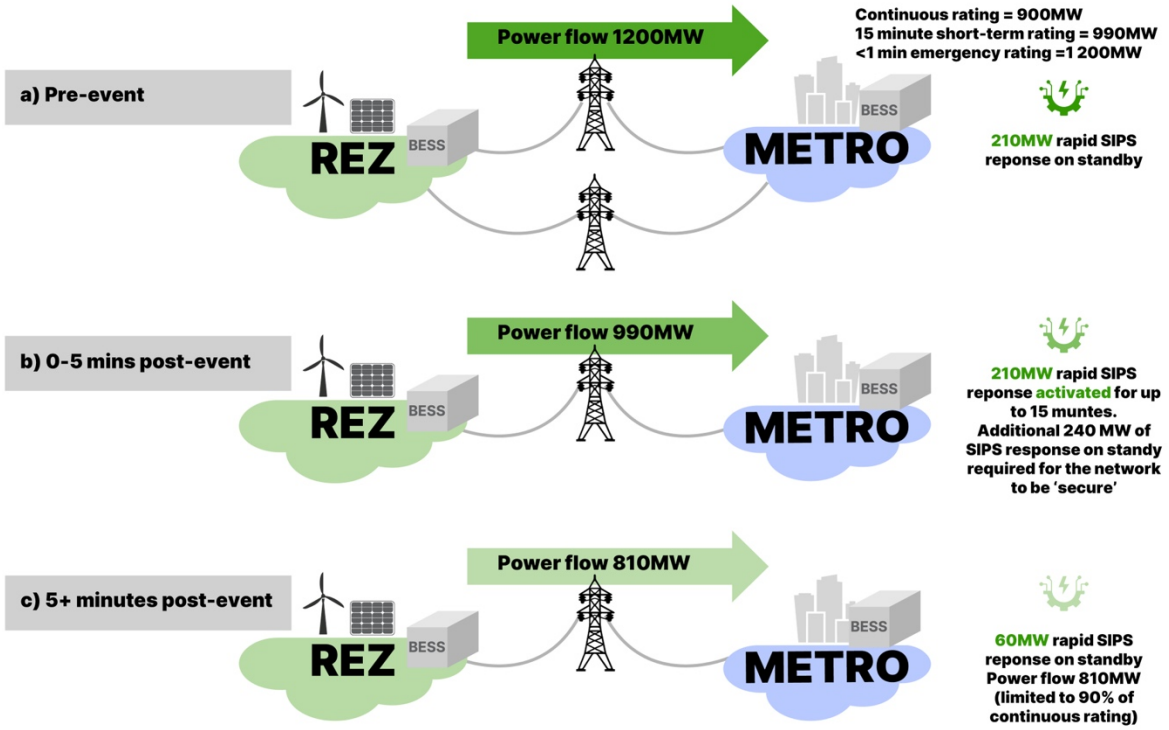
With Flexible BESS–SIPS Portfolio: The enablement of up to 210MW of metro BESS in a SIPS would potentially allow higher pre- and post-event power flow. Assuming lines can withstand 1200MW transfer for 300ms, 1200MW of pre-event power flow can be supported.

Immediately following the loss of a 330kV circuit, a SIPS reduces output from the REZ by 210MW (1200–210 = 990MW), as BESS in the Metro subregion discharges at 210MW, to manage circuit loading to 990MW. If the Metro BESS were charging prior to the event, it would reduce charging by 210MW. The System Operator has 30 minutes to resecure the network. The availability of a further 240MW (990–750 = 240MW) of battery capacity held in reserve for slower resecuring response would allow the System Operator to rapidly resecure the network by managing circuit loading to a secure 750MW, while generation is redispatched over a longer period. The 450MW of flexible reserve enables higher flow from the REZ while maintaining security for potentially longer durations than the BESS, providing "firmed capacity" in the form of energy dispatch.

Once generation is redispatched (5–30 minutes after the event), 60MW of battery capacity enabled for SIPS response will allow the System Operator to load the remaining circuit to 90% of continuous rating (810MW). Noting that the System Operator will operate lines up to 90% of continuous rating. The additional 60MW of SIPS response (810–750 = 60MW), reduces the net generation loss associated with trip of the remaining circuit to 750MW. This allows an additional 60MW of power flow from the REZ for the duration of the outage. Rather than dispatching 60MW of energy from the BESS via the energy market, the BESS is enabling additional power flow from the REZ.

The pre- and post- event power transfer for the example of a 330kV double circuit with a Flexible BESS–SIPS Portfolio is illustrated in Figure 2.

Figure 2: 330kV double circuit transmission line *with* Flexible BESS–SIPS Portfolio



Source: Author analysis

Post-event fast response within the REZ: can be achieved by co-ordinated trip or runback of generation, or a BESS within the REZ immediately charging or reducing output following an event.

Post-event fast response within the Metro Region: can be achieved by a BESS within the Metro subregion immediately discharging or reducing charging operation following an event.

Network planning documents can call for or include non-network options for strategically placed BESS, paired BESS or "storage-based alternatives" to transmission augmentation, as a way to enable additional transfer capacity that would ordinarily be inaccessible.[29]

The availability of interim reserve during the post-contingency resecuring phase increases network resilience by managing the risk associated with of the loss of the remaining line.

[29] AEMO. 2026 ISP Non-network options consultation. September 2026.

Example 2: 500kV double-circuit transmission

Power-transfer capacity benefits and the need for both rapid and slower resecuring responses are more apparent on a 500kV high-voltage, double-circuit transmission line. This example considers two parallel circuits, each rated at 3000MW (continuous), 3300MW (15 minutes, short term).

Without Flexible BESS–SIPS Portfolio: The maximum power transfer from the REZ could be limited to approximately 1950MW based on the assumption 1200MW of operating reserve is available to resecure the network following an event, and maximum flow on the remaining line after the redispatch of slower resecuring reserve is 750MW, (i.e. 1200+750 = 1950MW). The assumption of 1200MW of reserve is based on:

a) The maximum output of two 600MW synchronous generators, noting that the LOR framework requires reserve to manage the loss of two units. Note, on a high-demand day, the largest units in Victoria operate at 600MW.

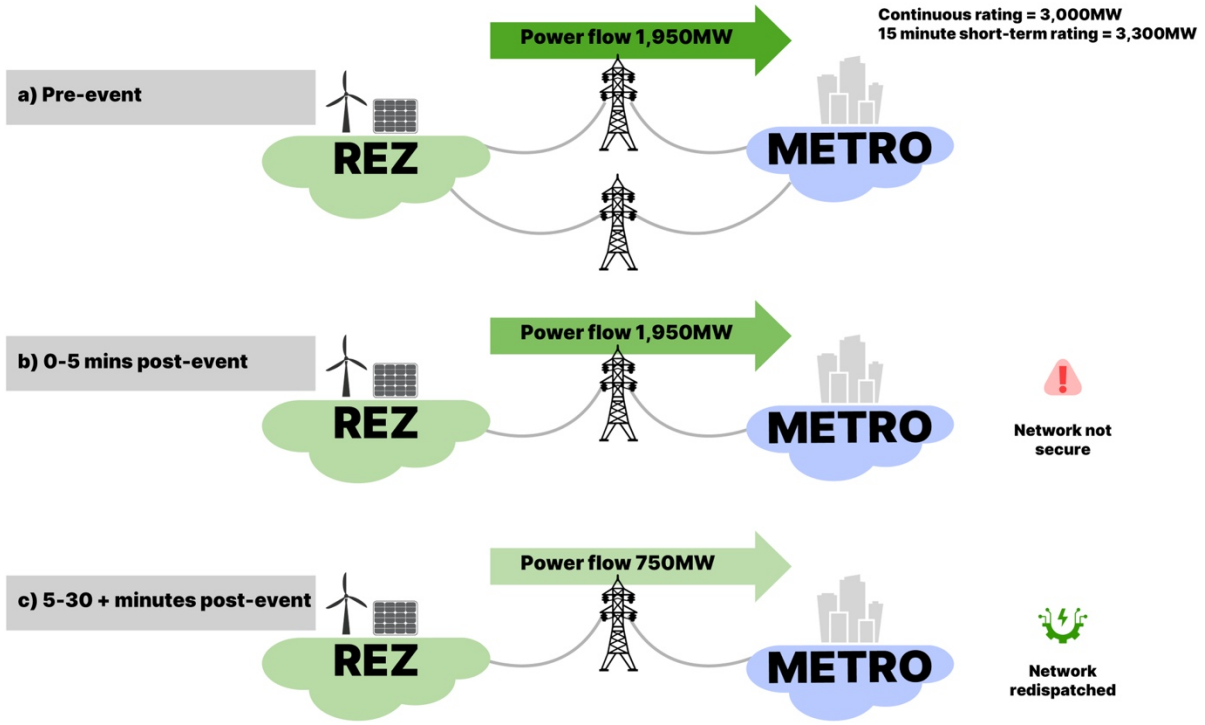
b) The approximate available generation headroom on four 600MW synchronous generators when operating at 50%. On a day of high renewable output with the minimum number of synchronous units online, synchronous generators are typically operating at minimum, and 1200MW of reserve can typically be sourced from four Loy Yang generators operating at 50%. However, as coal units retire, resecuring reserve will need to be provided by alternative energy sources.

The export capacity of 1950MW is well below the design capacity of the transmission line. This results in each line being loaded at 33% of total maximum capacity when all assets are in service.

Following the loss of a circuit, the remaining circuit transfers 1950MW. While this is within design rating, the line flow is greater than largest permissible loss of generation (750MW). In the event the remaining line is tripped, load will be shed. To resecure the network and maintain supply to load, 1200MW of generation will need to be redispatched over the next 30-minute period to reduce the power flow on the remaining line to 750MW. While this 1200MW of generation is redispatched, the network is not secure.

The pre- and post- event power transfer for the example of a 500kV double circuit without a Flexible BESS–SIPS Portfolio is illustrated in Figure 3.

Figure 3: 500kV double circuit transmission *without* Flexible BESS-SIPS Portfolio



Source: Author analysis

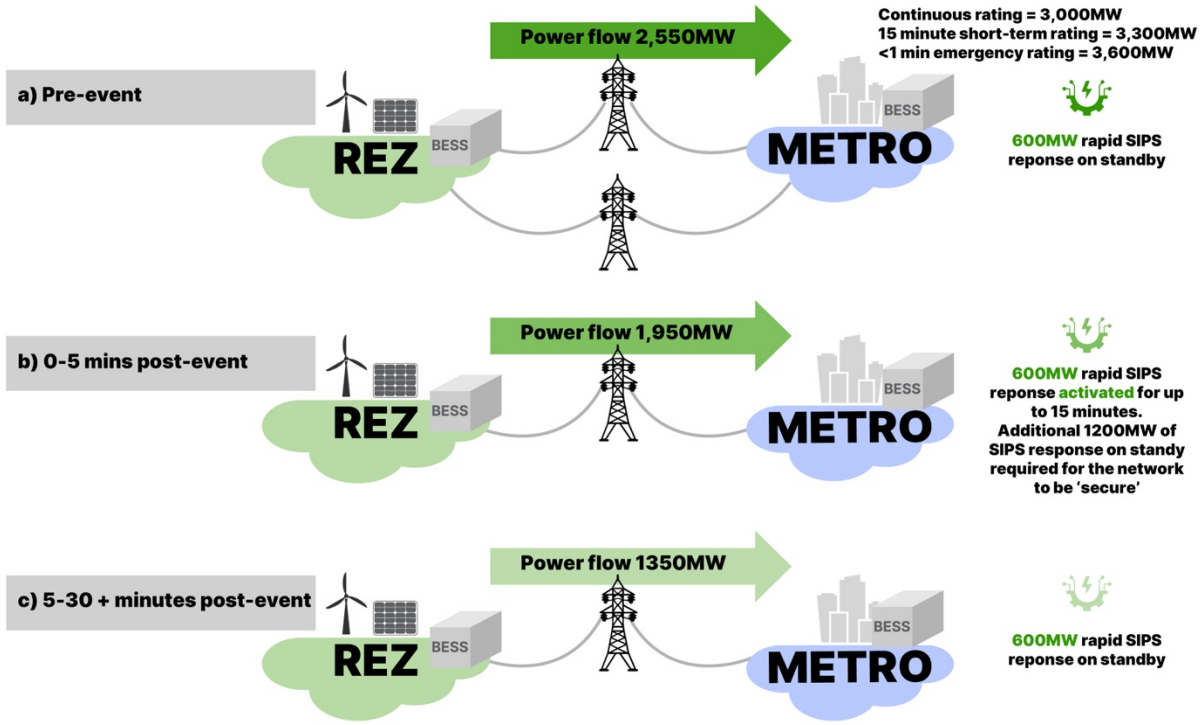
With Flexible BESS–SIPS Portfolio: To enable increased levels of pre-event power transfer from the REZ, additional battery capacity enabled for slower resecuring response would need to be available to the System Operator. The enablement of a further 600MW of BESS capacity for slower resecuring response would increase the power export from the REZ, NEMDE would need to redispatch a larger volume of generation (1800MW) within 25–30 minutes with greater network risks associated with the loss of the remaining line.

The enablement of up to 600MW Metro BESS in the Flexible BESS–SIPS Portfolio would potentially increase pre-event *and* post-event power flow on the 500kV transmission corridor by 600MW.

Dispatching 600MW of rapid SIPS response following the loss of a 500kV circuit, reduces post-event security (load shedding) risks associated with the loss of the remaining line. For the 30 minutes after the event, the network is redispatched every five minutes to resecure it. Optionally, a further 1200MW of SIPS response would allow the network to be resecured immediately rather than over a 30-minute period. Once sufficient generation is redispatched, the participating Metro BESS–SIPS Portfolio can revert to being enabled for rapid response to allow higher transfer from the REZ during the outage. Following the event, the BESS enables increased transfer capacity for durations that could exceed the firm supply capacity associated with stored energy within the BESS.

The pre- and post- event power transfer for the example of a 500kV double circuit with a Flexible BESS–SIPS Portfolio is illustrated in Figure 4.

Figure 4: 500kV double circuit transmission *with* Flexible BESS–SIPS Portfolio



Source: Author analysis

Post-event fast response within the REZ: can be achieved by co-ordinated trip or runback of generation, or a BESS within the REZ immediately charging or reducing output following an event.

Post-event fast response within the Metro subregion: can be achieved by a BESS within the Metro region immediately discharging or reducing charging operation following an event.

As in the previous example, the co-ordinated action of generator systems, one within the REZ and another outside the REZ, to enable increased power transfer can be thought of as a form of "virtual transmission", as it enables additional transfer capacity that would otherwise be inaccessible.

The concept is scaleable to accommodate participation from multiple BESS with reserve quantities calculated to provide optimised benefits on multiple transmission corridors. The concept could be extended to allow the definition of multiple subregions that indicate which BESS systems can participate in the post-event response.

A scheme with 600MW of Flexible BESS–SIPS Portfolio response has the potential to optimise power transfer on multiple corridors, noting that the likelihood of a single event affecting export from multiple REZ zones is unlikely.

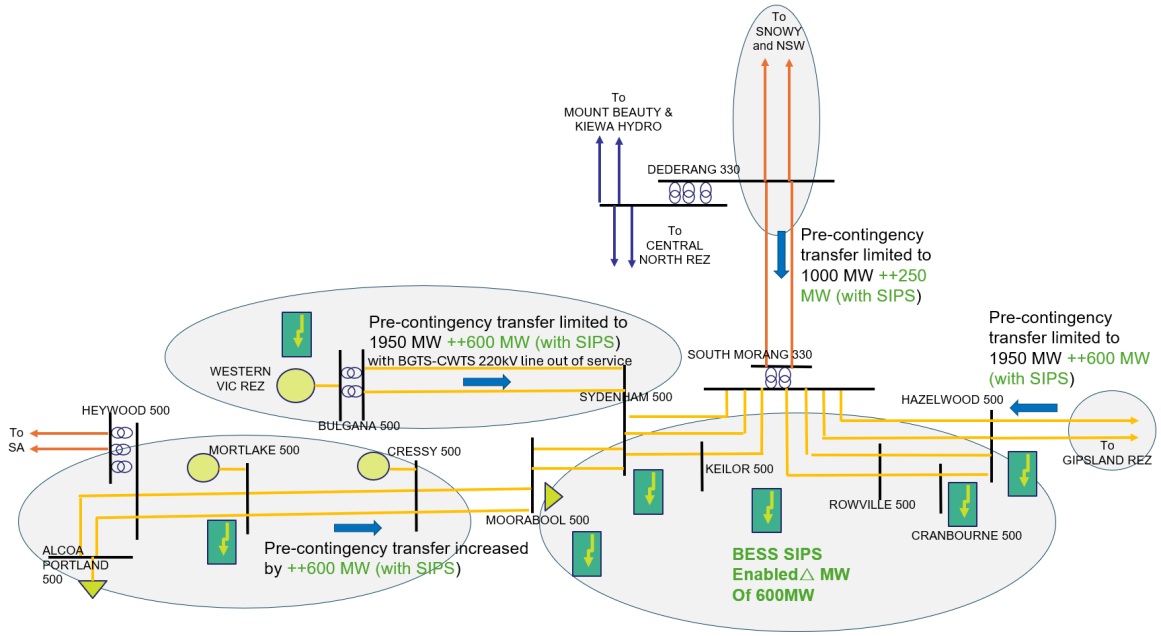
The response can be from multiple BESS to ensure the scheme does not rely on the action of one BESS facility. A portfolio of BESS provides voltage support, allows optimal dispatch from REZs while maintaining a minimum level of charge to meet security of supply requirements to local or co-located loads. A BESS may wish to offer a percentage of its total installed capacity to a network optimisation scheme.

With sufficient participation a portfolio of BESS could manage the loss of multiple lines during adverse weather events of increased risk to the network; for example, during periods when unlikely (non-credible) events are reclassified as likely (credible).

Potential application to the Victorian network is outlined in Figure 5.

Figure 5: Illustrative example – optimising power transfer on the future Victorian network

BESS portfolio	Transmission corridor	Potential uplift (MW)
600MW Victoria Metro BESS portfolio	NSW import (Murray–Dederang–South Morang 330kV)	+250 (VBB SIPS)
	Gippsland REZ Export (Hazelwood–South Morang 500kV)	+600
	SW REZ Export (Heywood–Moorabool 500kV)	+600
	WRL Western REZ Export (Bulgana–Sydenham 500kV)	+600



Source: Author analysis

Notes: The ability to introduce open circuit points on parallel transmission may be a requirement to achieve increased power transfers.

Reactive support provided by generator systems in the REZ will support high power transfers.

Following a network event, generation would need to be redispatched and the optimal level of Flexible BESS–SIPS Portfolio capacity on standby recalculated.

The above increases to power transfer are based on a specified SIPS availability of 600MW, associated with the management of a single network event.

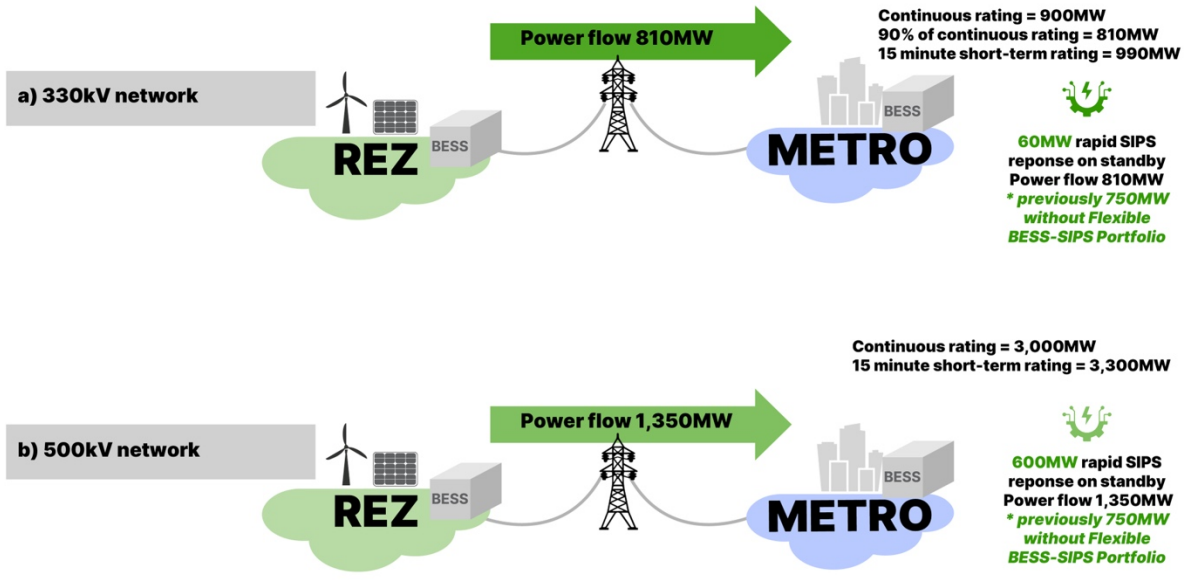
Managing power system transfer risks during outages

The impact of an outage (planned or forced) on a system with limited transmission capacity can be extreme. With limited transmission capacity, the inability of available renewable generation to supply the load becomes a major risk. Typically, planned outages are scheduled so that they do not coincide with periods of high demand. However, as load increases, the periods when outages can be scheduled may become shorter; alternatively, restrictions could be placed on demand levels or BESS charging capacity.

As indicated in the previous section, the transfer on a single transmission line can be limited by the largest permissible loss of generation, 750MW. Power transfer capacity can be increased if a Flexible BESS–SIPS Portfolio is available to reduce the net loss in power associated with the fault event. A similar approach can be taken to manage a potential loss of load that exceeded permissible levels.

Rather than a Metro BESS (or BESS portfolio) providing "firmed capacity" during periods of limited transmission capacity, a BESS (or BESS portfolio) providing reserve would contribute towards "firmed capacity" by increasing transfer capacity to allow additional energy dispatch from remote REZs. The concept of managing network outages with a Flexible BESS–SIPS Portfolio is illustrated in Figure 6.

Figure 6: Managing network outages *with* Flexible BESS–SIPS Portfolio



Source: Author analysis

Enabling load connection and battery charging

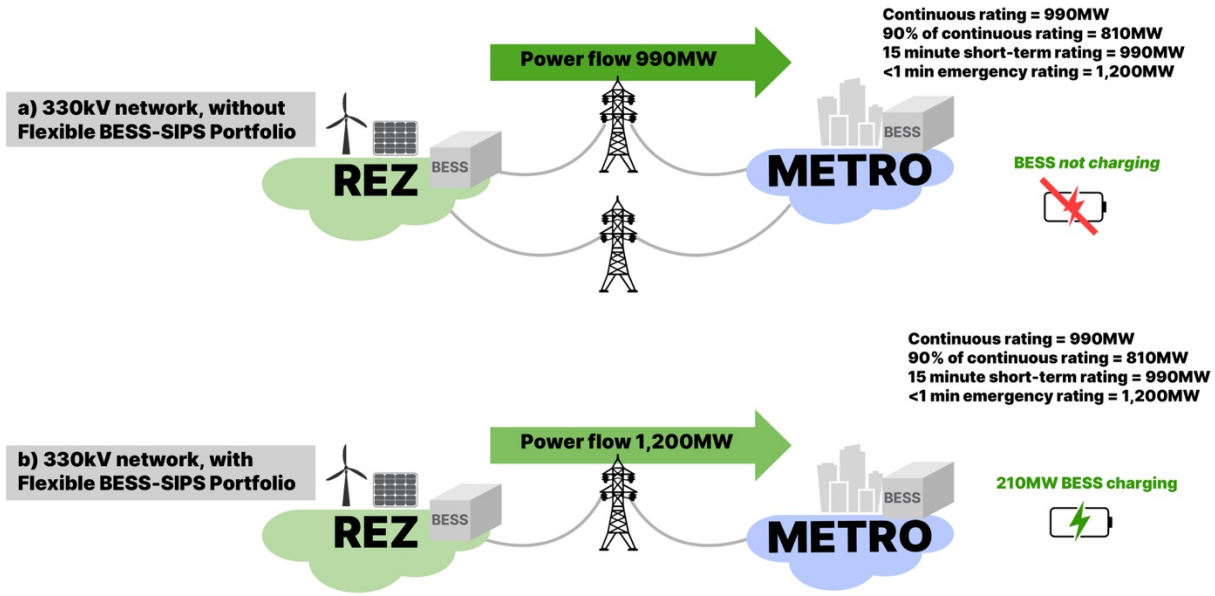
The ability to charge BESS systems at times of high renewable output and high load can be limited by transmission capacity. The co-ordinated discharge and charge of BESS systems on the network

could facilitate the redistribution of energy without affecting network security. The concept of co-ordinated BESS operation could allow batteries to charge at times when they may otherwise be restricted due to insufficient transmission capacity.

Maintaining a fleet of charged BESS ensures the availability of network resecuring reserve to maximise network power transfer while maintaining the ability to deliver energy supply to loads that need to ensure continuity of supply (security of supply) at a nearby point of connection.

The concept of enabling "flexible charging capacity" while participating in a Flexible BESS–SIPS Portfolio is illustrated in Figure 7. This example is essentially the same as Example 1; the difference is that here the Metro BESS is charging rather than enabled ready to discharge. Following the loss of a transmission line and generation runback, the Metro BESS would immediately stop charging.

Figure 7: Enabling flexible BESS charging capacity



Source: Author analysis

A portfolio of BESS participating in a reserve scheme could allow NEMDE to schedule windows for optimised charging and power transfer at times of low-price high renewables and at times of restricted transmission capacity.

An additional benefit of a portfolio of BESS is the ability to respond to loss of load events by quickly increasing BESS charging or decreasing BESS discharge thus supporting large loads by not only providing security of supply, and voltage support but by managing the impact of the load on the network in the event it disconnects.

Benefits

A Flexible BESS–SIPS Portfolio could deliver the following benefits:

- Increase REZ generator export and reduce curtailment of lower cost renewable energy in REZs, particularly at times of high demand to place downward pressure on wholesale energy prices.
- Improve network utilisation, reliability and the post-event co-ordination of generator system response.
- Support the connection of large loads, and avoid load tripping.

Renewable generation and large load developments typically have shorter development times than transmission networks. The proposed scheme is an operational function that overcomes operational constraints that limit generation dispatch and load supply. Enabling such a function aims to bridge the gap between the current and future network when investment in infrastructure will provide sufficient transmission capacity under all operating conditions.

Rather than pre-emptively constraining generation and reducing load to manage the impact of an event, should it occur, reserve can be enabled to respond to the event thereby providing an optimal solution to generator dispatch and load supply.

While many post-event schemes address specific events with a generation or load tripping, the use of a Flexible BESS–SIPS Portfolio is likely to provide benefits across the wider network.

Implementation

New System Operator function needed to unlock this opportunity

A new System Operator function is required to identify the need to reserve BESS capacity to enable increased power transfer. This function would calculate the optimal quantity of SIPS response to procure from available BESS participating in the service to increase power transfer across multiple transmission corridors. The System Operator function would likely enable the Flexible BESS–SIPS Portfolio during times of high dispatch from generator systems in a REZ, to enable the transmission line to run at a higher level to accommodate the increased flow of renewable generation. The function would signal to the BESS the responses required at given times.

The core ask of the System Operator function is the dynamic co-ordination of the flexible BESS–SIPS portfolio, co-optimising BESS response volumes to apply optimal uplift to constraints in NEMDE.

This report does not examine or determine an appropriate mechanism that would best enable the procurement of the Flexible BESS–SIPS Portfolio.

Market analysis is required to determine the appropriate mechanism to facilitate procurement of an optimised Flexible BESS–SIPS Portfolio. In the short term, it could be procured through existing non-market routes, such as government tenders, a TNSP network support agreement, an NSCAS contract, or a Type 1 or Type 2 Transitional Services contract. Longer term, a dedicated rule change could explore the benefits of establishing a new mechanism to procure the reserves associated, for example, through a new subregional reserve market similar to Powerlink's proposal.[30]

The success of the function would depend on BESS participation. While the promotion of market benefits could gain support from renewable generators, networks and consumers, BESS participation would be critical. At times of limited transmission capacity and/or supply capacity, market prices could be high therefore providing incentive for BESS to bid into the energy market for greater returns through arbitrage.

BESS systems enabled in a Flexible BESS–SIPS Portfolio could enable higher transmission capacity for longer periods than dispatching BESS energy for a limited number of hours. This can indirectly enable the dispatch of "firmed supply capacity" from the regions without depleting backup supply.

A system trial would help quantify the cost benefits of the new System Operator function. During a trial, the number and duration of periods when the Flexible BESS–SIPS Portfolio would be required, the available reserve capacity and the uplift in transfer capacity could be captured to calculate indicative $/MW benefit.

Limitations and potential challenges to address

Single batteries already provide SIPS responses in Australia (the Victorian Big Battery and Waratah Super Battery). In Germany, batteries support the transmission grid (Kupferzell).[31]

However, using a group of batteries together is new, and both detailed network modelling and a trial would be needed to test this concept. Another new aspect of the proposal outlined in this report is using a group of batteries to support multiple transmission lines (there is some precedent for this, with the single Waratah Super Battery supporting a number of transmission lines). This would also need to be tested through a study. Any such study should consider the following challenges and limitations:

- **Other limits may apply:** Some transmission lines are limited by voltage or stability rather than thermal capacity, and adding a Flexible BESS–SIPS Portfolio would add little extra capacity.

[30] Powerlink. Development of Regional/Subregional Frequency Control Ancillary Services (FCAS) and/or Operating Reserve Markets. 20 June 2023.
[31] TransnetBW. Network Booster Kupferzell.

- **More batteries, more communications:** Several batteries must respond following an event requiring fast, reliable communications. Risks associated with the failure of one battery to respond would need to be evaluated.
- **Batteries must be ready:** Batteries need enough charge to participate. The model also relies on owners choosing to take part, even when high prices make energy arbitrage more profitable.
- **Limited competition:** Some lines (particularly low-voltage corridors) may have only two or three suitable batteries nearby, so prices may need to be capped. Optimisation of power transfer on high-voltage lines increases the potential for more BESS to participate.
- **Benefits not yet proven:** The figures in this report are illustrative. Benefits will vary by line depending on voltage level and connectivity.

Conclusion

Enablement of a Flexible BESS–SIPS Portfolio can maximise REZ generator dispatch, network utilisation and support growth in Metropolitan load.

A new System Operator function would be needed to unlock this opportunity. This function would procure the Flexible BESS-SIPS Portfolio, as required, during times of high dispatch from generator systems in a REZ and/or high demand. Active BESS participation in this service would help enable the dispatch of lower cost renewable energy at minimal cost.

The AEMC should consider the ability of a Flexible BESS–SIPS Portfolio to provide "firming transmission capacity" when undertaking its Electricity Network Regulation Review.[32,33]

[32] AEMC. Electricity Network Regulation Review – Package 1. August 2026.
[33] AEMC. Electricity Network Regulation Review – Package 2. August 2026.

Appendix: Market and non-market services in the NEM

Category	Service type	Purpose	Procurement method	Activation	Typical providers
Market services	Energy market (spot market)	Balance supply and demand every 5min	Market bidding; AEMO dispatch	Continuous	Generators, batteries, demand response
	Frequency Control Ancillary Services (FCAS): Regulation (raise/lower)	Maintain frequency at 50Hz	Market bidding	Continuous	Batteries, fast generators
	FCAS contingency (6s, 60s, 5min)	Arrest and restore frequency after disturbances	Market bidding	Event-driven	Batteries, synchronous plant
	Fast Frequency Response (FFR)	Very fast stabilisation (<2s)	Market bidding	Event-driven	Batteries, advanced IBRs
Non-market ancillary services	Network Support & Control Ancillary Services (NSCAS)	Address network limitations (voltage, stability, constraint relief)	Bilateral contracts	As required	Synchronous plant, network equipment, some batteries
	System Restart Ancillary Services (SRAS)	Restart the power system after a blackout	Competitive tender	During system black events	Generators with black-start capability
	Transitional services (Type 1 & Type 2)	Provide emerging or innovative security services (MSL support, synthetic inertia, grid-forming trials)	Competitive tender, direct RFO, unsolicited offers	Continuous or event-driven	Batteries, IBRs, hybrid assets
Non-market contracted security	Reliability and Emergency Reserve Trader (RERT)	Provide emergency reserve when reliability standard at risk	Contracted reserve; tenders or direct procurement	Only during tight reliability conditions	Demand response, generators, batteries
	System Integrity Protection Scheme (SIPS)	Fast active power injection to support transmission stability and increase transfer limits	Regulated contract; competitive tender	Triggered by specific faults	Network control schemes, generators, large batteries (e.g. WSB, VBB)
	Contracted Inertia/ System Strength Services (TNSP-led)	Provide minimum inertia or system strength as required by jurisdictional frameworks	TNSP procurement	As required	Synchronous condensers, batteries, STATCOMs
	Other bespoke reserve/security contracts	Jurisdiction-specific reliability or security arrangements	Jurisdictional procurement	As defined	Generators, batteries, demand response

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