Transgrid

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Meeting system strength requirements in NSW

RIT-T Project Assessment Conclusions Report (PACR)

Region: New South Wales

Date of issue: 14 July 2025

Executive summary

Transgrid is responsible for ensuring sufficient system strength services are available to maintain the stability of the NSW power system. The forecast retirement of NSW coal generators in the coming decade (80% retiring by capacity) and the growth in inverter-based resources (IBRs) is driving an urgent need to add new sources of system strength.

A network without adequate system strength will result in stability issues and supply interruptions to end consumers. Generators may be unable to remain connected during disturbances on the power system, control of the system voltage becomes more difficult, and protection systems that ensure safe operation of the network may not operate correctly.

> *"The [AEMC Reliability] Panel emphasises the urgency of system security investment to keep pace with the transition... the Panel is of the view that to keep pace with the energy transition, security needs must be identified earlier so that timely investment can occur. Security risks are emerging faster than expected. For example, system strength and minimum system load have become critical risks earlier than expected, and market interventions have been needed to maintain system security."*
>
> *"... the risks of over- and under-investment are asymmetric. The risk of over-investment in security services, or investment earlier than needed, comes with much lower costs than under-investment or investment that is too late. Under-investment could lead to periods when the NEM cannot be securely operated."*
>
> **AEMC Reliability Panel, April 2025** [1]

New requirements apply for Transgrid as the System Strength Service Provider

As the System Strength Service Provider (SSSP) for NSW, Transgrid is applying the Regulatory Investment Test for Transmission (RIT-T) to assess options that meet our National Electricity Rule (NER) obligations. This refers specifically to clause S5.1.14 to deliver system strength services to the NSW power system to meet standards set by AEMO from 2 December 2025. The standards are designed to ensure the safe and secure operation of the power system ('minimum' level) and to facilitate the stable voltage waveform ('efficient' level) of new IBRs.

This RIT-T examines network and non-network solutions to comply with system strength requirements and to maximise net economic benefits to the National Electricity Market (NEM) and ultimately to consumers.[2]

The PACR has benefited from stakeholder consultation

Publication of this PACR is the final stage of the RIT-T process. It follows publication of the Project Specification Consultation Report (PSCR) in December 2022, the Project Assessment Draft Report (PADR) in June 2024 and the PADR Supplementary Report in October 2024.

[1] AEMC Reliability Panel, 23 April 2025, Letter to AEMO: Reliability Panel comments on AEMO's Transition Plan for System Security

[2] This is a 'reliability corrective action' under the RIT-T as the options considered are for the purpose of meeting externally imposed regulatory obligations and service standards, i.e., Clause S5.1.14 of the NER.

The analysis has been strongly informed by stakeholder consultation, and we thank all parties for their valuable input throughout this RIT-T. We received eight stakeholder submissions over the course of the RIT-T and engaged in Joint Planning activities with AEMO, other SSSPs, Ausgrid and EnergyCo.

The PACR refines PADR inputs and assumptions using latest information

The overall characterisation of the identified need has not changed since the PADR and the PADR Supplementary Report. The PACR refines and updates assumptions and approaches to reflect latest information, including:

- updated delivery dates for the New England REZ Network Infrastructure project;
- updates to the Hunter-Central Coast REZ Network Infrastructure project being delivered by Ausgrid;
- revised delivery schedule for Central West Orana REZ synchronous condensers to align with a schedule provided to Transgrid by EnergyCo;
- a new sensitivity on the revised timing and quantum of IBR within the South West REZ, aligned to the recently awarded Access Rights to 4.3 GW of IBR capacity;
- updated information on each individual non-network solution, including Transgrid's assessment of technical and commercial feasibility of each non-network solution;
- independent assessment by GHD of the technical feasibility and implication of additional hours of operation of NSW hydro and gas units for system strength provision;
- advanced investigations of network (Transgrid) synchronous condenser costs, lead-times and market capacity through market sounding of suppliers and site assessments; and
- PSCAD studies of grid-forming Battery Energy Storage Systems (BESS), including all major suppliers, to further assess their ability to provide stable voltage waveform support.

The PACR has assessed more than 100 individual solutions

Transgrid undertook an EOI for system strength services from third-party proponents (i.e. entities that could provide system strength services to Transgrid under a non-network system security contract). Transgrid received submissions from 30 parties, covering over 60 individual potential solutions, including:

- > 14 GW of existing or modifications of existing synchronous generators;
- > 3 GW of other new generation and energy storage projects, including pumped hydro, gas and compressed air storage;
- > 7.5 GW of grid-forming BESS; and
- several non-network synchronous condensers.

Transgrid has also assessed 46 additional individual solutions including grid-forming BESS and synchronous condensers in network locations identified as optimal for system strength provision.

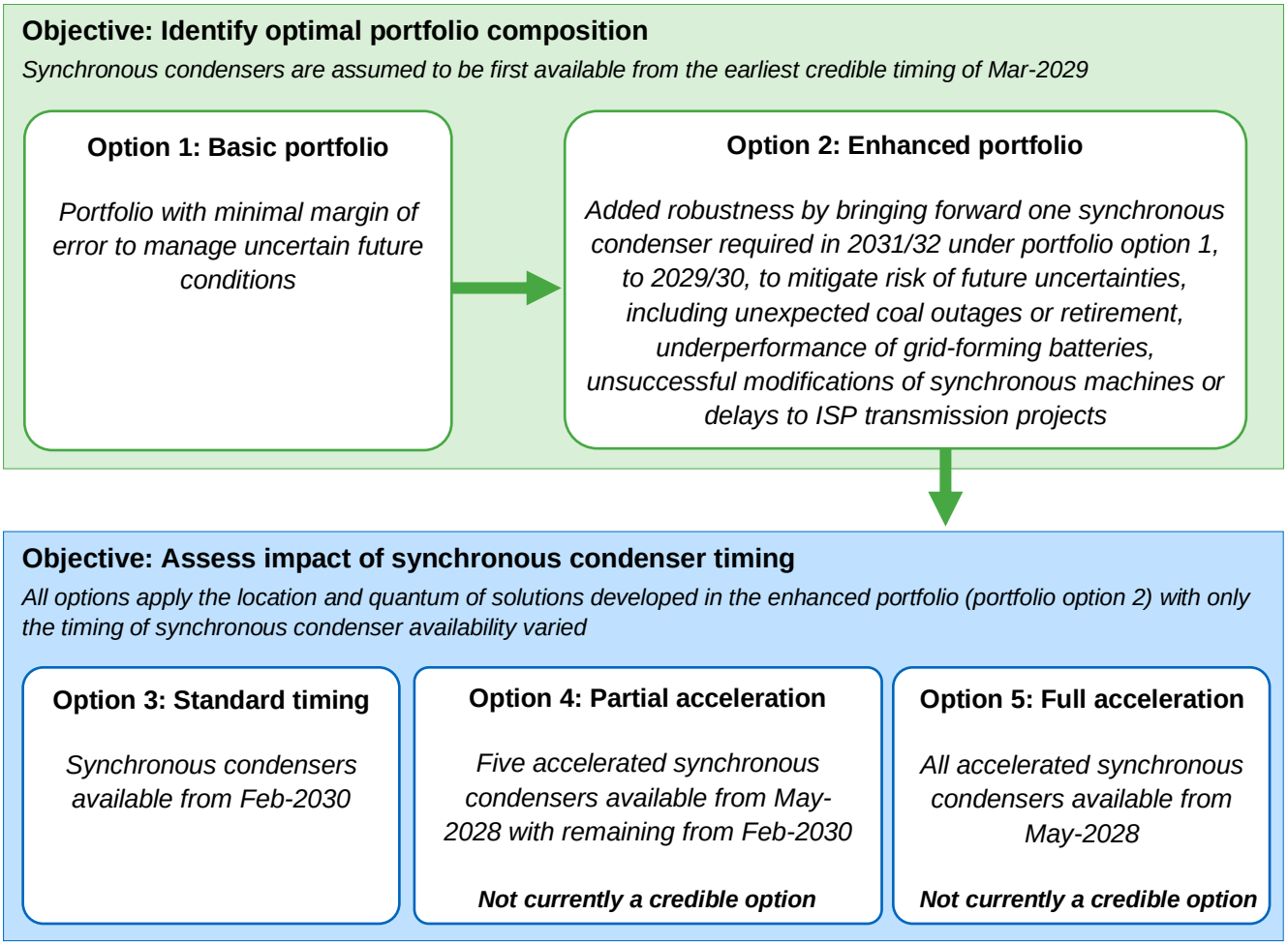
Five portfolio options have been assessed in this RIT-T

In light of the scale of NSW's system strength requirements, the objective of the PACR was to identify an optimal 'portfolio option' (being a portfolio of individual system strength solutions) which met our requirements while maximising the present value net market benefits.

Different portfolio options were then created by varying the assumed timing of synchronous condensers.

Currently, only portfolio options 1, 2 and 3 are credible as portfolio options 4 and 5 assume synchronous condensers are available earlier (May 2028) than considered credible. Transgrid identified the credible timing synchronous condensers are first available is between March 2029 and February 2030. The range of credible timing reflects uncertainty in factors external to Transgrid, including the lead-time of synchronous condensers, the regulatory approval process with the Australian Energy Regulator (AER) and the dispute process for this PACR. In all portfolio options, the delivery of each subsequent synchronous condenser is staggered by 1.5-months.

Figure 1. Summary of portfolio options in this PACR [3]



Portfolio options 4 and 5 are only expected to be credible if Transgrid commences procurement of synchronous condensers before the AER's approval of a Contingent Project Application. However, insights from our market modelling show that if these two options were proven to be credible, there would be significant additional net market benefits.

[3] Portfolio option 1 of the PACR follows the same methodology as portfolio option 1 of the PADR which was considered the most credible option for the PADR. The names of the other portfolio options for the PACR do not link to the names used in the PADR.

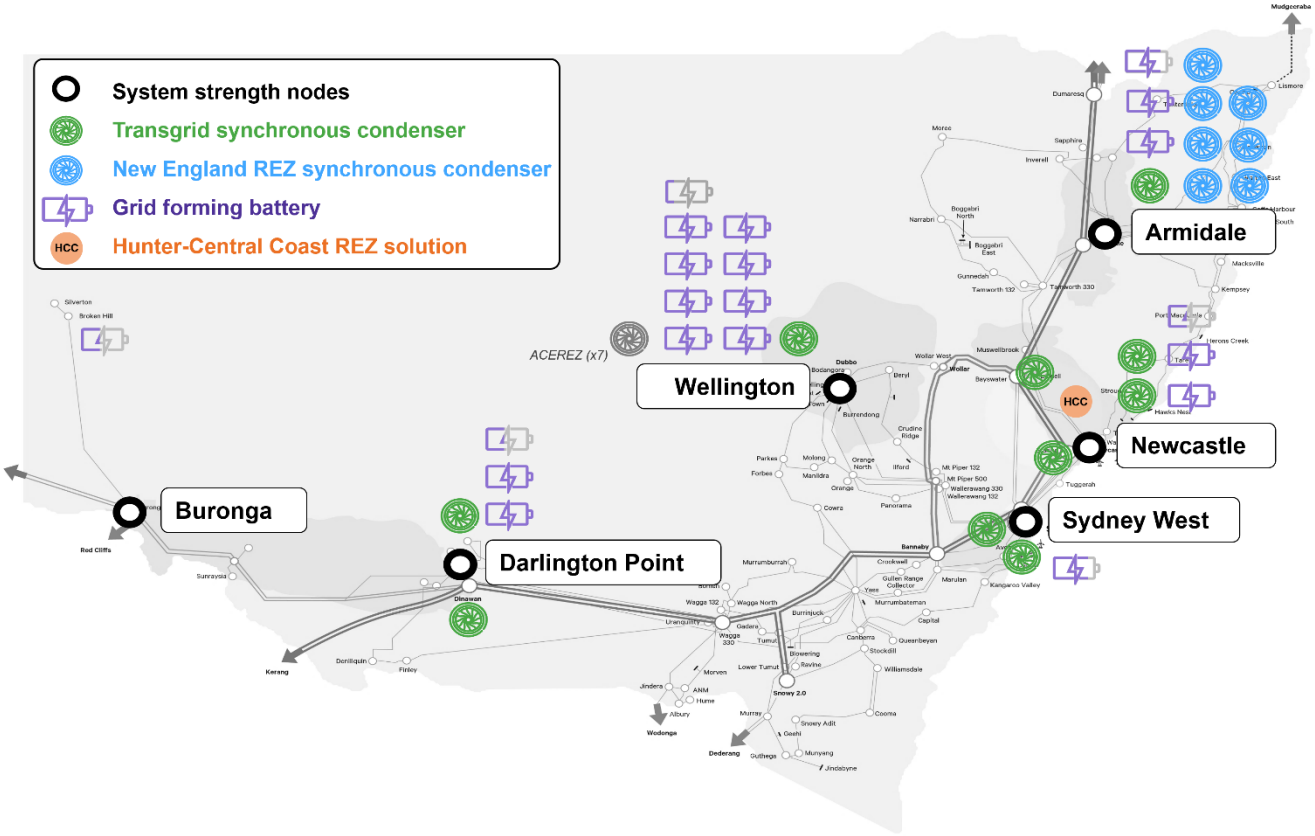
Portfolio options share key themes

Portfolio options share key themes, including:

- new sources of system strength are needed rapidly to replace retiring coal units;
- 're-dispatch' (increase in operating hours) of synchronous generators (hydro, gas, coal) is important in the next five years before new system strength solutions come online;
- grid-forming batteries are a cost-effective source of system strength to facilitate renewable generation when already committed for energy market purposes; and
- once deployed, grid-forming batteries and synchronous condensers form the core solution set to meet medium to long-term system strength needs.

A geographic representation of new-build system strength solutions[4] in portfolio option 2 (preferred credible option) is presented in Figure 2, broadly grouped by system strength node.

Figure 2. Indicative map of new-build system strength solutions in portfolio option 2 (where each grid-forming battery icon represents the equivalent contribution to the efficient level of system strength as one synchronous condenser)



Network (Transgrid) synchronous condensers include remediation for the South West REZ. Synchronous condensers required for the New England REZ may be delivered by a third-party network operator and solutions for Hunter-Central Coast REZ will be procured as non-network solutions (discussed below).

[4] excluding upgrades to synchronous machines for commercial sensitivity.

New build system strength solutions

Table 1 presents the composition and timing of each portfolio option.

- Portfolio option 1 ('basic portfolio') has been formed through a market and power system modelling co-optimisation to meet energy market and system strength needs in NSW. The output produces a portfolio of system strength solutions which has minimal margin of error to manage uncertain future conditions;
- Portfolio option 2 ('enhanced portfolio') brings forward one synchronous condenser identified as required in 2031/32 in portfolio option 1, to 2029/30. This adjustment adds robustness to the portfolio to mitigate risks related to future uncertainties on the availability of system strength in NSW; and
- Portfolio options 3 – 5 vary the timing of network synchronous condensers to identify the optimal timing of Transgrid synchronous condensers. The composition of the portfolio of solutions is identical to portfolio option 2.

Table 1. New-build solutions for each portfolio option

	2025/26	2026/27	2027/28	2028/29	2029/30	2030/31	2031/32	2032/33	By 2044/45
Transgrid network synchronous condensers Cumulative number of units (each providing 1,050MVA fault current), see note 1									
Portfolio 1	-	-	-	3	9	9	9	9	9
Portfolio 2	-	-	-	3	10	10	10	10	10
Portfolio 3	-	-	-	-	4	10	10	10	10
Portfolio 4	-	-	2	5	9	10	10	10	10
Portfolio 5	-	-	2	9	10	10	10	10	10
New England REZ synchronous condensers Cumulative number of units (each providing 1,050MVA fault current), see note 2									
Portfolio 1	-	-	-	-	-	-	6	8	8
Portfolio 2 - 5	-	-	-	-	-	-	5	7	7
Upgrades to synchronous machine to allow synchronous condenser mode Cumulative capacity (MW)									
All portfolios	50	50	300	650	650	650	650	650	650
Grid-forming BESS Cumulative capacity (MW)									
All portfolios	-	1,350	3,250	3,650	4,150	4,800	4,800	4,950	8,150

Note 1: If synchronous condensers with a fault level contribution of <950MVA are selected through Transgrid's procurement process (calculated using unsaturated reactance), an additional one synchronous condenser is required between 2028/29 and 2030/31 in the Sydney West or Newcastle region (date is unique to each option).

Note 2: Solutions for New England REZ are separately itemised as EnergyCo may adopt an approach outside of the NER framework, where central system strength remediation is the responsibility of a third-party network operator (rather than Transgrid as the SSSP for NSW). Transgrid will not progress the procurement of solutions for New England REZ until EnergyCo's approach has been confirmed.

Table 1 excludes:

- New build solutions for Hunter-Central Coast REZ. Solutions are required from 2027/28, being either four smaller non-network synchronous condensers (275 MVA fault level each) or 200 MW of non-network grid-forming batteries. Non-network solutions were not able to be fully assessed given arrangements for the distribution-connected REZ were only recently announced. Transgrid will carry out a procurement process to identify the preferred solution and proponent; and
- Seven synchronous condensers being deployed in Central West Orana REZ by ACEREZ, as these are outside the scope of this RIT-T.

Our modelling identifies that 5 GW of grid-forming batteries (by 2032/33) provides the equivalent stable voltage waveform support as approximately 17 synchronous condensers. We expect the 5 GW of grid-forming BESS will contribute to growing confidence in the technology to support system strength and enable testing to potentially contribute to the minimum level of system strength over time.

Costs of the portfolio of system strength solutions

Given the magnitude of the identified need, there are significant costs across all portfolio options. We estimate total capital and operating costs for the full 20-year horizon to 2044/45 for the preferred credible portfolio option 2 as (undiscounted 2023/24 dollars):[5]

Network (Transgrid) costs include:

- $1,608 million capital costs and $157 million operating costs for new synchronous condensers.

New England REZ synchronous condenser costs (proponent to be identified by EnergyCo):

- $1,077 million capital costs and $89 million operating costs for REZ synchronous condensers.

Non-network costs include:

- $181 million capital costs and $18 million operating costs for system strength solutions for the Hunter-Central Coast REZ;
- $18 million capital costs and no incremental operating costs for upgrades to existing and new synchronous generators to enable synchronous condenser capability; and
- $2,644 million capital costs and $476 million operating costs for grid-forming BESS including new-build and upgrades of committed/anticipated and ISP-modelled solutions to enable grid forming capability.

Table 2 summarises the total capital and operating costs for each portfolio option over the full 20-year assessment period, excluding re-dispatch costs.

[5] All costs in the PACR are presented in 2023/24 dollars unless otherwise specified. Please note that these costs do not map directly to the costs Transgrid expects to recover via the regulatory control process (e.g., the unit upgrades to allow synchronous condenser mode operation and new grid-forming BESS build would be incurred by proponents of these solutions who would then charge Transgrid an operating cost to cover their costs). Costs exclude re-dispatch costs.

Table 2. Summary of portfolio costs over the 20-year assessment period – undiscounted 2023/24 dollars, $m

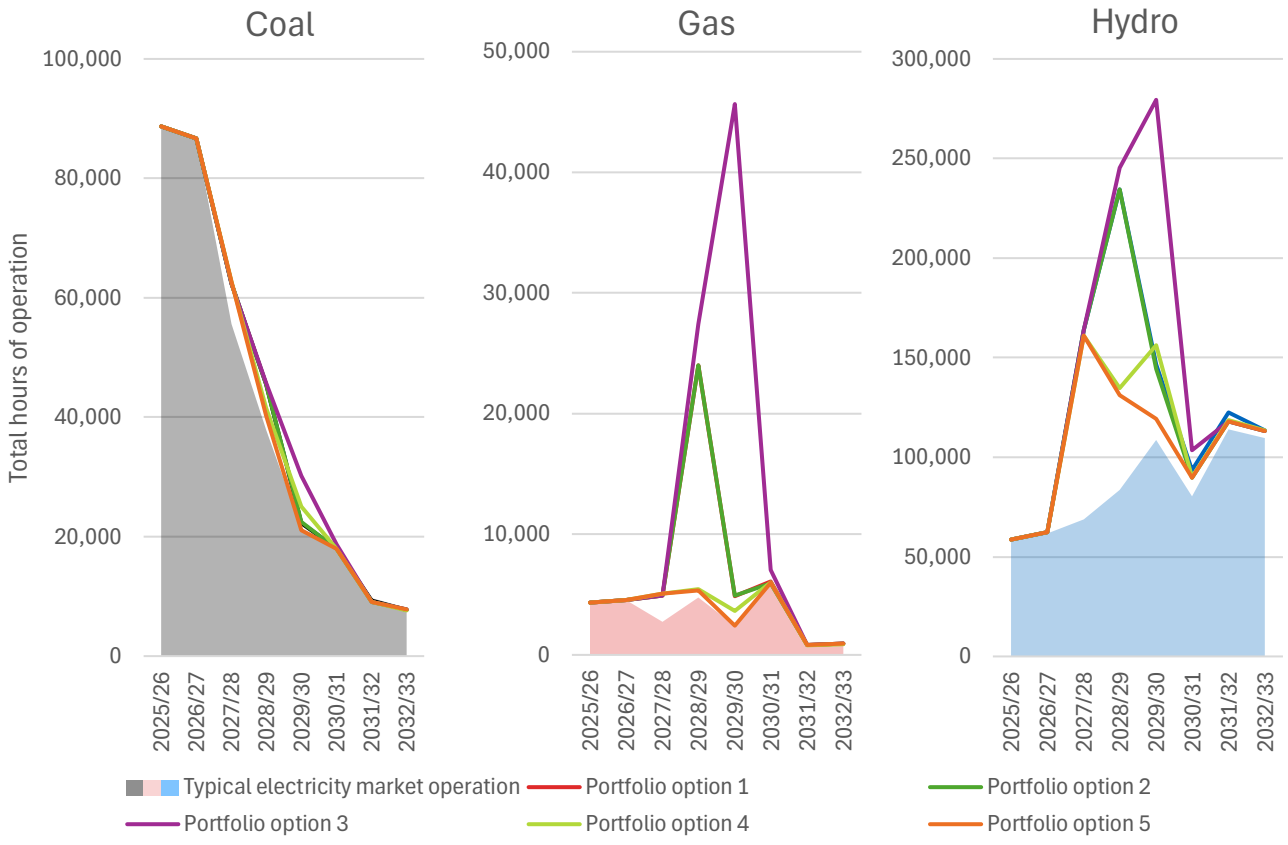
	Portfolio option 1	Portfolio option 2	Portfolio option 3	Portfolio option 4	Portfolio option 5
Capex $m	5,511	5,528	5,528	5,528	5,528
Opex $m	737	740	732	743	748
Total $m	**6,248**	**6,269**	**6,260**	**6,271**	**6,276**

Non-network solutions will be enabled via non-network system security contracts with Transgrid. Contract costs are treated as a wealth transfer under the RIT-T (and have no bearing on the Net Present Value (NPV) results),[6] however are expected to have a material impact on the ultimate cost to end consumers.

Re-dispatch of synchronous generators is vital over the next five years

'Re-dispatch' (increase in operating hours compared to typical market operations) of synchronous generators is a critical part of all portfolio options to meet the minimum level of system strength before synchronous condensers are available. Total hours of operation for each portfolio option are shown in Figure 3 (lines), compared with typical hours of operation modelled for electricity market purposes only (shaded area).

Figure 3. Re-dispatch of synchronous machines across all portfolio options to 2032/33



[6] AER, October 2023, Regulatory investment test for transmission – application guidelines (Final decision)

All portfolio options rely on some hydro re-dispatch to meet needs in the first two years (no coal or gas re-dispatch). Portfolio options 4 and 5 exhibit materially lower re-dispatch in 2028/29 and 2029/30 because of the earlier deployment of synchronous condensers.

Portfolio options 1 - 3 rely heavily on gas re-dispatch to meet the need in years 2028/29 and 2029/30. Transgrid's market modelling includes a daily NEM-wide gas constraint (consistent with AEMO's 2024 ISP) and a specific additional pipeline constraint for two NSW gas generators (consistent with GHD advice). However, a comprehensive assessment of gas pipeline capacity and gas supply availability was out of scope for this assessment. As such, modelling may over-estimate the possible re-dispatch of gas, which may result in an underestimate for forecast risks of system strength gaps.

Accelerated deployment of synchronous condensers reduces the risk of gaps in system strength

Modelling for each portfolio option identifies the risk of gaps to the minimum level of system strength. The risk of gaps occurs before synchronous condensers can be sufficiently deployed, as shown in Table 3. Risks are highest during periods of co-incident generation maintenance or forced outages.

Table 3. Years where the risk of system strength gaps occur for portfolio options 1 - 5

	Portfolio option 1	Portfolio option 2	Portfolio option 3	Portfolio option 4	Portfolio option 5
2025/26	No gaps	No gaps	No gaps	No gaps	No gaps
2026/27	No gaps	No gaps	No gaps	No gaps	No gaps
2027/28	Risk of gaps	Risk of gaps	Risk of gaps	Risk of gaps	Risk of gaps
2028/29	Risk of gaps	Risk of gaps	Risk of gaps	No gaps	No gaps
2029/30	No gaps	No gaps	Risk of gaps	No gaps	No gaps
2030/31	No gaps	No gaps	No gaps	No gaps	No gaps
2031/32	No gaps	No gaps	No gaps	No gaps	No gaps
2032/33	No gaps	No gaps	No gaps	No gaps	No gaps

Risks of gaps in the minimum level of system strength are projected to occur for:[7]

- up to 2% of time in 2027/28 across all portfolio options after the closure of Eraring Power Station;
- up to 1.5% of time in 2028/29 for portfolio options 1 – 3 at all nodes other than Armidale, and up to 10% of time at Armidale; and
- up to 5% of time in 2029/30 for portfolio option 3 at all nodes other than Armidale, and over 20% of time at Armidale.

Risks of gaps during critical planned outages may be partially mitigated if transmission outages can be co-ordinated with periods of high coal generation availability.

Transgrid is working to enable earlier procurement and installation of synchronous condensers to minimise power system security risks. In the operational timeframe, Transgrid will support AEMO and other relevant parties to manage the risks of insufficient system strength.

[7] Note that the assessment of risks of gaps in system strength is subject to market modelling assumptions. Gaps may be more or less in reality.

Portfolio option 2 is the preferred credible option

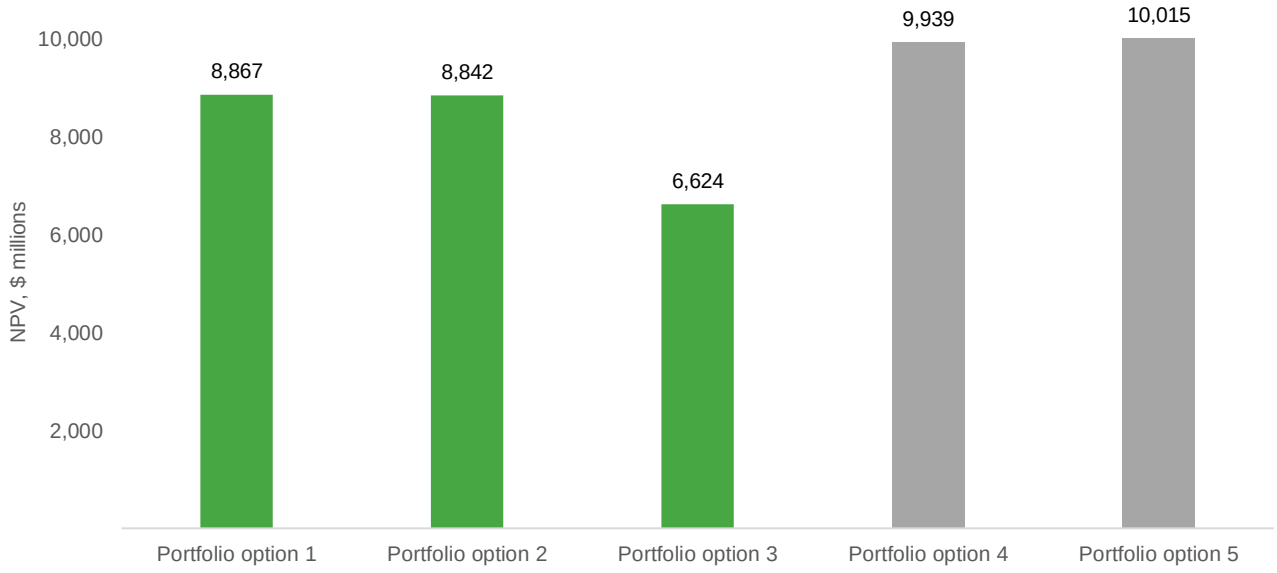
Figure 4 summarises the headline NPV results for each portfolio option. All portfolio options are found to generate substantial net market benefits over the assessment period – at least $6.6 billion in net benefits, in present value terms.[8] These benefits are primarily attributable to:

- avoided gaps in system strength (and therefore avoided unserved energy); and
- avoided generator fuel costs and lower emissions associated with lower re-dispatch of synchronous machines.

Portfolio options 1, 2 and 3 are the credible portfolio options identified in this PACR:

- portfolio options 1 and 2 are within a margin of error (difference in net market benefits of $25 million or 0.28% and a difference in total portfolio capital costs of $21 million or 0.33%); and
- portfolio option 3 has the lowest net benefits due to the delay in synchronous condenser delivery ($2.2 billion lower than portfolio option 2).

Figure 4. Headline NPV results for portfolio option 1 – 5; green indicates currently credible portfolio options; grey indicates a portfolio option that is not yet credible, but would deliver additional market and consumer benefits



The enhanced portfolio (portfolio option 2) provides increased resilience to the NSW power system by bringing forward one synchronous condenser identified as required in 2031/32 in portfolio option 1, to 2029/30. Increased resilience would support power system security in situations such as more significant generator unplanned outages or longer than expected maintenance, earlier coal retirements, higher-than-expected IBR deployment, delays to contracting with or availability of non-network solutions or delays to ISP transmission projects such as HumeLink, Hunter Transmission Project or VNI West.

The net market benefits of the basic portfolio (portfolio option 1) and enhanced portfolio (portfolio option 2) are very similar; the difference between the two is within the margin of error for the assessment. This

[8] Note that 'at least' is used here and throughout the report when discussing the headline net market benefits. This is on account of the approach taken to remove the avoided unserved energy that is common to all option portfolios from the assessment, as it does not assist with ranking the portfolio options. If this unserved energy is added to the analysis, the expected net benefit of all portfolio options would be significantly greater.

justifies bringing forward one synchronous condenser earlier in the assessment period to increase the resilience of the portfolio to different states of the world relative to the assumptions modelled. As such, the enhanced portfolio (portfolio option 2) is considered the preferred credible option for this RIT-T.

Accelerating synchronous condensers will deliver materially more market benefits

Portfolio options 4 and 5 are not currently credible. However, if the accelerated procurement of Transgrid synchronous condensers is confirmed as credible, this would lead to higher net market benefits, specifically:

- a $3.3 billion increase in net market benefits when five network synchronous condensers are accelerated (portfolio option 4 compared to 3), or $1.1 billion compared to portfolio option 2; and
- a $3.4 billion increase in net market benefits when ten network synchronous condensers are accelerated (portfolio option 5 compared to 3), or $1.2 billion compared to portfolio option 2.

Earlier deployment of synchronous condensers also delivers a more resilient power system and enables earlier achievement of 100% instantaneous renewables in NSW, which supports government emissions reduction goals.

Full acceleration of network synchronous condensers (portfolio option 5) has $76 million higher net market benefits than partial acceleration (portfolio option 4). Transgrid expect the difference in net market benefits to be larger in reality as portfolio option 5 is more resilient to a range of plausible events including more significant generator unplanned outages or maintenance, earlier coal retirements, higher than expected IBR deployment, delays to contracting with or availability of non-network solutions or delays to ISP transmission projects such as HumeLink, Hunter Transmission Project or VNI West.

Two case studies indicate additional net market benefits of portfolio option 5 (not included in Figure 4), including:

- if the timing of South West REZ IBR build-out is consistent with advice from EnergyCo, portfolio option 5 has an additional $20 million benefits relative to portfolio option 4; and
- added resilience benefit to manage risk of delays to major transmission projects. For example, if the Hunter Transmission Project was delivered two years later than assumed in AEMO's 2024 Integrated System Plan, portfolio option 5 has an additional $30 million benefits relative to portfolio option 4.

Providing resilience to future uncertainties is consistent with the AEMC Reliability Panel's view[9] on the asymmetric risk of early or late-investment in system strength (or over and under-investment), as quoted: *"the risks of over- and under-investment are asymmetric. The risk of over-investment in security services, or investment earlier than needed, comes with much lower costs than under-investment or investment that is too late. Under-investment could lead to periods when the NEM cannot be securely operated."*

In recognition of the urgency of system strength requirements, Transgrid is currently engaging with suppliers and collaborating with relevant stakeholders to enable the regulatory and procurement process to progress as quickly as possible. Following publication of the PACR, Transgrid will continue this work to

[9] AEMC Reliability Panel, 23 April 2025, Letter to AEMO: Reliability Panel comments on AEMO's Transition Plan for System Security *and* AEMC, 2021, Final Rule: Efficient management of system strength on the power system

deliver Transgrid synchronous condensers as soon as possible, with the goal to reduce power system security risks and maximise net market benefits.

Next steps

This PACR is the final stage in the RIT-T process.

Portfolio option 2 is currently the preferred credible portfolio option. It would be replaced as the preferred option by portfolio option 4 or 5 if the accelerated procurement of synchronous condensers became credible.

Parties wishing to raise a dispute notice with the AER may do so prior to 18 August 2025 (30 days after publication of this PACR). Further details on the RIT-T can be obtained from Transgrid's Regulation team via regulatory.consultation@transgrid.com.au.

Transgrid will commence procurement and regulatory processes for individual solutions identified by the preferred portfolio of system strength solutions, including:

- network solutions (synchronous condensers): Transgrid will submit a contingent project application to the AER once all triggers have been met; and
- non-network solutions: Following procurement processes, Transgrid will assess whether the non-network solutions meet criteria for efficient and prudent expenditure. For eligible contracts, Transgrid will seek a determination from the AER and, when successful, will execute with proponents.

Future system strength requirements will continually change, including due to revised IBR forecasts within AEMO's annual System Strength Report. Transgrid will use non-network solutions to provide flexibility in how the preferred portfolio of solutions identified through this RIT-T meets the evolving needs of the NSW power system.