Transgrid

Maintaining reliable supply to Broken Hill

RIT-T - Project Assessment Conclusions Report

Region: South Western New South Wales

Date of issue: 26 May 2022

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Executive summary

Broken Hill is located in the far west of New South Wales (NSW) and is part of our south-western transmission network. It is currently supplied by a single 220 kV transmission line, 'Line X2', from Buronga which spans approximately 260 km.

When Line X2 is out of service due to planned or unplanned outage, electricity supply to Broken Hill is supported by two diesel-fired turbines (currently owned by Essential Energy) to avoid involuntary load shedding. We rely on these turbines to meet the NSW Electricity Transmission Reliability and Performance Standards 2017 (the 'reliability standards') set by the NSW Energy Minister and regulated by the NSW Independent Pricing and Regulatory Tribunal (IPART).

Essential Energy notified us in late-2018 of its decision to divest the turbines located at Broken Hill. Without action, this would result in the required reliability of supply to Broken Hill not being maintained, and involuntary load shedding when Line X2 is on a planned or unplanned outage.

This Regulatory Investment Test for Transmission (RIT-T) process was initiated in November 2019 to assess options for continuing to provide reliable supply to Broken Hill. Publication of this PACR represents the final stage in the RIT-T process and follows the revised Project Assessment Draft Report (PADR) released on 6 October 2021.

Overview

The PACR finds that the continued operation of the existing diesel-fired turbines as an interim measure, followed by network support provided by the Hydrostor compressed air storage solution (Option 1A(4)) is the top-ranked option, followed closely followed by refurbishing and continuing the long-term use of the existing diesel-fired turbines (Option 2). Option 1A(4) is projected to deliver approximately $286 million in net benefits over the 27 year assessment period (on a weighted-basis), which is approximately 5.8 per cent greater than Option 2.

This finding marks a change from the conclusion in the PADR, which found Option 2 to be the top-ranked option (by a 9 to 12 per cent margin over Option 1A(2)), and reflects both an increase in the estimated wholesale market benefit from the energy storage solution (following alignment with the assumptions in the draft 2022 ISP released in December 2022) and that Hydrostor now expects to secure a significant external funding contribution from ARENA for Option 1A(4).

In addition to having a marginally greater expected net benefit, we consider Option 1A(4) to be preferred over Option 2 at this stage since it:

- uses a clean technology that is consistent with the general transition of the electricity sector to low emission technologies – Option 2 has an enduring reliance on fossil fuel technologies as part of the long term solution to meet reliability standards at Broken Hill, which we consider less preferable in the context of the general transition of the electricity sector to low emission technologies, and the Sustainability Strategy of Broken Hill City Council;
- supports the use of innovative solutions to meeting network needs, which may provide an example that can be adopted more widely – we have undertaken a holistic review and are confident that the compressed-air energy storage solution is technically feasible (this review has been supported by an independent technical assurance report from Aurecon);
- is able to efficiently accommodate additional mining load at Broken Hill, should it eventuate – Option 2 would require coupling with additional components to meet this additional load, which

would increase the future costs of this option and, potentially, compromise the level of reliability provided to customers in Broken Hill;

- has a lower level of unavailability due to outages (which reduces the risk of disruptions to customer supply in Broken Hill) – Option 2 requires significant refurbishment of the existing turbines that requires them to be out of service while this is undertaken; and
- is expected to have a further modest increase in net benefits if more available transmission capacity west of Wagga Wagga is assumed as a result of the anticipated investment under the separate RIT-T Transgrid is currently finalising to alleviate a voltage stability limit at Darlington Point – this development would not affect the net benefits of Option 2.

Notwithstanding the above, we consider that if either of the following two events occur, they would likely constitute a 'material change in circumstances' (i.e., under clause 5.16.4(z3) of the NER):

1. ARENA and Hydrostor not being able to finalise a funding agreement with a sufficient upfront external capital contribution; or
2. Transgrid and Hydrostor not being able to finalise a network support contract that is expected to be accepted as prudent and efficient by the AER.

Should either of these events occur, we would seek an exemption from the AER under clause 5.16.4(z3) of the NER to avoid having to reapply the RIT-T. Specifically, we consider that, should either of the above events occur, then the analysis in this PACR demonstrates that Option 2 should then be considered the preferred option under this RIT-T, unless Hydrostor were to decide to pursue a smaller-scale option (Option 1A(2)), which would then become the preferred option, even in the absence of external funding.

We consider this approach provides sufficient confidence that Transgrid will be able to progress an option to ensure the required reliability to consumers at Broken Hill at an efficient cost level without having to re-do the RIT-T. We note that re-doing the RIT-T would take significant time, which would compromise the reliability of supply to customers at Broken Hill and ultimately likely cost all NSW electricity customers more in the long-run.

We will be liaising closely with ARENA and Hydrostor to monitor how Option 1A(4) progresses through the various 'stage gates' ARENA has identified for its funding, in order to assess whether the above conditions are expected to be met within the timeframes outlined in this PACR.

In terms of the required external capital contribution, we consider a 'sufficient' amount to be an amount that results in Option 1A(4) being either within 5 per cent of, or outright preferred to, Option 2 on a weighted basis across the three scenarios assessed. While we note that this value depends on a range of factors, including the assumed cost of Option 1A(4) and the profile of the funding contribution, we currently consider this value to be at least $13.2 million if provided in full up-front, based on the PACR assessment.

We will update stakeholders when we consider either that both the external funding agreement and the network support agreement for Option 1A(4) are sufficiently certain, or at the point we determine there has been a material change in circumstances and that either Option 2 or Option 1A(2) should instead be progressed (i.e., when we would submit an exemption to the AER from having to reapply the RIT-T).

Assuming Option 1A(4) is progressed, the start-date for the network support contract would coincide with the expected commissioning date for the compressed-air solution in 2025/26.

Both Option 1A(4) and Option 2 are expected to generate sufficient benefits to recover their costs within ten years of commissioning their respective long-term solutions (under the weighted results).

Benefits from the options considered in this PACR

We consider this a 'reliability corrective action' under the RIT-T, as the identified need is to ensure that the externally-imposed IPART reliability standards for Broken Hill continue to be met. Without action, the required reliability of supply to Broken Hill would not be maintained, and there would likely be involuntary load shedding when Line X2 is on a planned or unplanned outage.

We are taking action under this RIT-T in order to avoid this outcome. All of the credible options assessed in this PACR provide back-up and reliable supply to Broken Hill for the future that is consistent with the NSW reliability standard and so avoid significant amounts of unserved energy to consumers in Broken Hill.

In addition, some of the credible options assessed also affect the wholesale electricity market. In particular:

- some options involve grid-connected storage that introduce new entities trading in the wholesale market, eg, dispatching into the National Electricity Market (NEM) outside of the allocation of storage needed to meet its Broken Hill network support commitments; and
- the impact on network capacity under some of the options facilitates greater uptake of renewables in surrounding Renewable Energy Zone (REZ) areas.

Both the benefits from the provision of reliable supply to Broken Hill and wider wholesale market benefits have been estimated as part of this PACR.

Key developments since the PADR have been reflected in the PACR

There have been a number of key developments since the revised PADR was released in October 2021 that have affected the analysis in this PACR. In particular:

- AEMO released its draft 2022 Integrated System Plan (ISP) in December 2021 – the wholesale market modelling in this RIT-T has been updated to reflect the assumptions underpinning the draft 2022 ISP, and the wholesale market benefits have also now been explicitly modelled for AEMO's step-change, progressive change and hydrogen superpower scenarios;
- the proponent of Option 1A(4) (Hydrostor) expects to secure funding from the Australian Renewable Energy Agency (ARENA) for its 200MW/1500MWh compressed-air energy storage solution, which has been included in the RIT-T analysis as 'external funding' for Option 1A(4); and
- the battery component of Option 1D has been progressed independently by the proponent (AGL) to a stage where we now consider a smaller-scale battery to be appropriately treated as an effectively 'committed' investment, and included in the base case for this RIT-T. As a consequence, only the incremental capital cost of increasing the size of this battery to provide network support is now reflected in the RIT-T assessment.

In addition, Transgrid agreed in January 2022 to purchase the existing turbines from Essential Energy to ensure supply reliability at Broken Hill is not compromised ahead of the optimal long-term solution being able to be implemented. The continued use of the existing diesel-fired turbines is the only way for us to meet our supply reliability obligations at Broken Hill in the immediate term and, based on the findings of the PADR, we consider this purchase to be a 'no regrets' decision as the continued use of the existing turbines, at least in the near-term, was found to be a common feature across all three of the top-ranked options in the PADR assessment. All options assessed in the PACR require continued use of the diesel-fired turbines in the short-term to continue to meet the reliability standards at Broken Hill, prior to the delivery and

commissioning of the main option components, with the exception of Option 1D and Option 2 (both of which require the on-going use of the existing diesel-fired turbines).

We also note that a number of options are no longer being assessed in this RIT-T:

- Hydrostor has withdrawn the different sizes of its compressed air energy storage solution that were included in the PADR, other than Option 1A(4), (i.e., Option 1A(1), Option 1A(2), Option 1A(3) and Option 1A(5) have all been withdrawn by the proponent);
- the proponent of Option 1C/5C, Option 5B and Option 1E/5E from the PADR has withdrawn these options,[1] and so they are no longer included in the RIT-T assessment; and
- Options 5A(1)-(5), which involved Transgrid ownership of a compressed-air-energy storage facility built by Hydrostor are no longer considered credible options as Hydrostor has now indicated its preference to proceed with Option 1A(4) only as a non-network solution.

In addition, we received submissions from four parties in response to the PADR. While submissions covered a range of topics, there were six broad topics that were most commented on:

- support for the use of a compressed-air energy storage solution;
- concern with the reliability of options involving diesel turbines over the long-term, and inconsistency with clean energy goals;
- interaction with potential new mining loads at Broken Hill; and
- the need for consistency with the latest ISP.

The key matters raised in submissions relevant to the RIT-T assessment are summarised in this PACR, together with our responses and how the matters raised have been reflected in the assessment.

The PACR assessment covers five different types of credible options

Stakeholder consultation over the course of this RIT-T has assisted greatly with developing and refining the credible options considered. Specifically, consultation with third parties has enabled this PACR to assess the following five types of credible options:

- Option 1: three different non-network opex solutions, predominantly provided by third parties:
  - Option 1A(4): a 200MW/1500MWh compressed-air energy storage solution provided by Hydrostor;
  - Option 1D: use of the existing 50 MW diesel-fired turbines acquired by the proponent, AGL (and provided to Transgrid as a service), 50MW/75MWh battery and 10 MW demand management; and
  - Option 1F: 100MW/800MWh liquid-air energy storage.
- Option 2: Transgrid acquiring the existing turbines from Essential Energy and refurbishing them as required over the long-term.
  - The costs of this option have been updated since the PADR, based on more accurate information on both the acquisition price and subsequent refurbishment costs;
- Option 3: establishing new diesel-fired turbines at Broken Hill;
- Option 4: building a second single circuit 220 kV transmission line from Buronga to Broken Hill; and
- Option 5G: 50MW/275MWh thermal energy storage, to be wholly or partially owned by Transgrid.

[1] Option 1C/5C involved a 73MW/292MWh battery, Option 5B involved a 62.5MW/250MWh battery and Option 1E/5E involved a 222MW/444MWh battery.

All options reduce expected unserved energy (EUE) at Broken Hill to the amount required under the IPART reliability standard. Option 4 provides an additional level of reliability due to the second transmission line and is assessed to reduce EUE to effectively zero.

Aside from Option 1D and Option 2, which require the on-going use of the existing diesel-fired turbines, all options require continued use of the diesel-fired turbines in the short-term to continue to meet the reliability standards at Broken Hill, prior to the delivery and commissioning of the main option components. It is assumed that Transgrid would own and operate the existing turbines for this interim period.

In order to maintain confidentiality of commercial-in-confidence information in submissions, proponent costs, and cost structures, have not been presented in this PACR.

Three scenarios have been assessed

The RIT-T is focused on identifying the top-ranked credible option in terms of expected net benefits. However, uncertainty exists in terms of estimating future inputs and variables (termed future 'states of the world').

To deal with this uncertainty, the NER requires that costs and market benefits for each credible option are estimated under reasonable scenarios and then weighted based on the likelihood of each scenario to determine a weighted ('expected') net benefit. It is this 'expected' net benefit that is used to rank credible options and identify the preferred option.

The credible options have been assessed under three scenarios as part of this PACR assessment, which differ in terms of the key drivers of the estimated net market benefits.

The three alternative scenarios are characterised as follows:

- a 'low net economic benefits' scenario, involving a number of assumptions that gives a lower bound and conservative estimate of net present value of net economic benefits;
- a 'central' scenario which consists of assumptions that reflect our central set of variable estimates that provides the most likely scenario; and
- a 'high net economic benefits' scenario that reflects a set of assumptions which have been selected to investigate an upper bound of net economic benefits.

The table below summarises the specific key variables that influence the net benefits of the options under each of the scenarios considered.

Table E-1: Summary of scenarios

Variable	Central	Low net economic benefits	High net economic benefits
Network capital costs	Base estimate	Base estimate + 25%	Base estimate - 25%
Non-network costs	Base estimate	Base estimate + 25%	Base estimate - 25%
Broken Hill demand	Based on POE50 demand forecast	Based on POE90 demand forecast	Based on POE10 demand forecast
Wholesale market benefits estimated	EY estimated based on the step-change 2022 ISP scenario	EY estimated based on the progressive change 2022 ISP scenario	EY estimated based on the hydrogen superpower 2022 ISP scenario
VCR	$37.78/kWh	$26.45/kWh	$49.12/kWh
Discount rate	5.50%	7.50%	1.96%

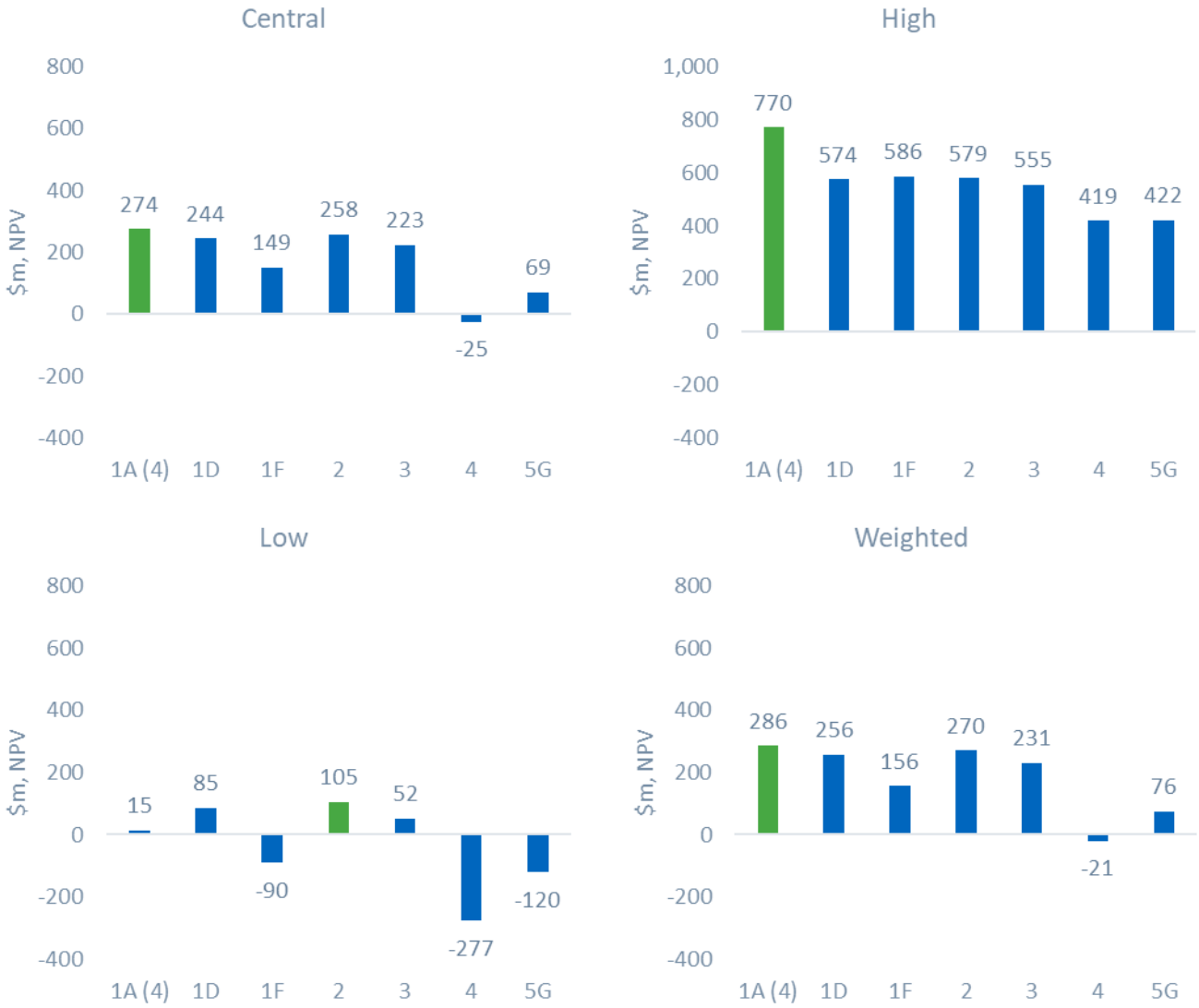
The wholesale market modelling has been updated since the PADR and we now model the market benefits of the options (where relevant) across the three key 2022 ISP scenarios. We have also weighted each of the scenarios for this RIT-T based on the draft 2022 ISP weightings for the underlying ISP scenarios, i.e.:

- 52 per cent to central scenario (based on the step-change scenario in the ISP);
- 30 per cent to the low benefits scenario (based on the progressive change scenario in the ISP); and
- 18 per cent to the high benefits scenario (based on the hydrogen superpower scenario in the ISP).

The Hydrostor network support option is the preferred option

The PACR assessment finds that network support delivered by Option 1A(4) is the preferred option under the RIT-T, closely followed by Option 2. Option 1A(4) is expected to deliver $286 million in net benefits over the 27 year assessment period (on a weighted-basis), which is 5.8 per cent greater than the net benefits expected from Option 2.

Figure E-1.1: Estimated net benefits for each scenario



This finding marks a change from the conclusion in the PADR, which found Option 2 to be the top-ranked option (by between 9 to 12 per cent over a smaller-sized Hydrostor solution (i.e., Option 1A(2)[2])), and reflects both the increase in the market benefits now expected from the Hydrostor option under the updated market modelling and that Hydrostor now expects to secure a significant external funding contribution from ARENA for Option 1A(4). Specifically, the RIT-T assessment of Option 1A(4) in this PACR reflects $45 million of external funding from ARENA, which reduces the cost of this option in the assessment.

The vast majority of the estimated wholesale market benefits for the Option 1A(4) in each scenario comes from its ability to defer, or avoid, significant costs associated with the construction of new, more expensive generation and/or storage capacity in the NEM. In contrast, Option 2 does not allow for any wider wholesale market benefits as the turbines are currently configured to operate only in islanded mode (and

[2] Specifically, the net benefits of Option 1A/5A(2) were found in the revised PADR to be within 9 to 12 per cent of the net benefits of Option 2, on a weighted basis, across base case I and base case II, respectively. As noted above, Option 1A(2) is considered as a sensitivity in section 7.5.7 in this PACR, given that Hydrostor is now focussing on Option 1A(4). See section 6.1 of the revised PADR for why two base cases were modelled at that stage of the RIT-T and section 2.2.4 of this PACR for why only one base case is now considered relevant.

sensitivity testing found that retrofitting them to enable them to dispatch in the wholesale market is not net beneficial).

We have tested the robustness of the conclusion to a number of other sensitivity tests as part of this PACR – namely:

- an increase in the capacity of the 330 kV transmission system west of Wagga Wagga, consistent with the outcome of the concurrent 'improving stability in south-western NSW' RIT-T;
- the existing turbines in Option 2 being retro-fitted to be able to dispatch to the NEM and generate wholesale market benefits;
- assuming new mining spot load development in the Broken Hill area;
- alternate commercial discount rate assumptions;
- different scenario weightings (i.e., those adopted in the PADR);
- the assumed profile of the external ARENA funding; and
- a decision by Hydrostor to revert to a smaller-sized solution (i.e., Option 1A(2) from the PADR), with no ARENA funding.

These sensitivities confirm that Option 1A(4) is the preferred option, closely followed by Option 2,[3] and that Option 1A(4) has potential additional benefits from being able to meet any additional future mining load without needing to incur additional option costs, and if there is an increase in the capacity of the 330 kV transmission system west of Wagga Wagga.

The last sensitivity above finds that, if Hydrostor and ARENA were not able to conclude an external funding agreement to progress Option 1A(4), and Hydrostor reverted to providing the network support via the smaller sized Option 1A(2) without any external funding, this option would then become the preferred option under the RIT-T (albeit ranked equally with Option 2).

Non-network support provided by Hydrostor using its compressed-air energy storage solution is the preferred option

The assessment in this PACR finds that network support provided by the Hydrostor compressed air storage solution (Option 1A(4)) is the top-ranked option, followed closely followed by refurbishing and continuing the long-term use of the existing diesel-fired turbines (Option 2). Option 1A(4) is projected to deliver approximately $286 million in net benefits, which is approximately 5.8 per cent greater than Option 2.[4]

Option 1A(4) involves Transgrid acquiring the existing diesel turbines at Broken Hill from Essential Energy and temporarily using them to provide network support at Broken Hill ahead of Hydrostor installing a 200MW/1500MWh compressed-air energy storage solution that will create a mini-grid at Broken Hill (at which point the turbines will be de-commissioned), and entering into a network support agreement with Transgrid. It involves 50MW and 250MWh dedicated in reserve at all times for reliability support services at Broken Hill and, when not called upon to provide the required reliability, the compressed-air energy storage components would participate in, and add liquidity to, the NEM wholesale market.

[3] The one exception to this is the high discount rate sensitivity (7.50 per cent), which finds that Option 2 becomes the highest ranked option, delivering benefits 12 per cent greater than Option 1A(4).

[4] If the external ARENA funding is removed from the assessment, Option 2 becomes the preferred option (unless Hydrostor were to decide to pursue the smaller Option 1A(2) – see section 7.5.7).

In addition to having a marginally greater expected net benefit, we consider Option 1A(4) to be preferred over Option 2 at this stage since it:

- uses a clean technology that is consistent with the general transition of the electricity sector to low emission technologies – Option 2 has an enduring reliance on fossil fuel technologies as part of the long term solution to meet reliability standards at Broken Hill, which we consider less preferable in the context of the general transition of the electricity sector to low emission technologies, and the Sustainability Strategy of Broken Hill City Council;[5]
- supports the use of innovative solutions to meeting network needs, which may provide an example that can be adopted more widely – we have undertaken a holistic review and are confident that the compressed-air energy storage solution is technically feasible (this review has been supported by an independent technical assurance report from Aurecon);
- is able to efficiently accommodate additional mining load at Broken Hill, should it eventuate – Option 2 would require coupling with additional components to meet this additional load, which would increase the future costs of this option and, potentially, compromise the level of reliability provided to customers in Broken Hill;
- has a lower level of unavailability due to outages (which reduces the risk of disruptions to customer supply in Broken Hill) – Option 2 requires significant refurbishment of the existing turbines that requires them to be out of service while this is undertaken; and
- is expected to have a further modest increase in net benefits if more available transmission capacity west of Wagga Wagga is assumed as a result of the anticipated investment under the separate RIT-T Transgrid is currently finalising to alleviate a voltage stability limit at Darlington Point – this development would not affect the net benefits of Option 2.

Notwithstanding the above, we consider that if either of the following two events occur, they would likely constitute a 'material change in circumstances' (i.e., under clause 5.16.4(z3) of the NER):

1. ARENA and Hydrostor not being able to finalise a funding agreement with a sufficient upfront external capital contribution; or

2. Transgrid and Hydrostor not being able to finalise a network support contract that is expected to be accepted as prudent and efficient by the AER.

However, should either of these events occur, we would seek an exemption from the AER under clause 5.16.4(z3) of the NER to avoid having to reapply the RIT-T. Specifically, we consider that, should either of the above events occur, then the analysis in this PADR demonstrates that Option 2 should be considered the preferred option under this RIT-T (unless Hydrostor were to decide to provide the network support solution via a smaller scale option (i.e., Option 1A(2)), in which case this would then be considered to be the preferred option, as outlined in section 7.5.7).

We consider this approach provides sufficient confidence that Transgrid will be able to progress an option to ensure the required reliability to consumers at Broken Hill at an efficient cost level without having to re-do the RIT-T. We note that re-doing the RIT-T would take significant time, which would compromise the reliability of supply to customers at Broken Hill and ultimately likely cost all NSW electricity customers more in the long-run.

[5] Broken Hill City Council, *Sustainability Strategy 2018-2023*.

We note that the application of the 'material change in circumstances' provision in the Rules (and the ability to include a 'decision rule' in a PACR), are currently being considered by Australian Energy Market Commission.[6] In the event that the NER changes following this PACR, we would consider the two events above to constitute two elements of a decision rule for ultimately determining the preferred option for this RIT-T if circumstances change.

We will be liaising closely with ARENA and Hydrostor to monitor how Option 1A(4) progresses through the various 'stage gates' ARENA has identified for its funding, in order to assess whether the above conditions are expected to be met within the timeframes outlined in this PACR.

We note that the assumptions around external funding reflected in this PACR are consistent with information provided by ARENA to Transgrid, but that the agreement remains subject to negotiation between ARENA and Hydrostor.

In terms of the upfront capital contribution, we consider a 'sufficient' amount to be an amount that results in Option 1A(4) being either within 5 per cent of, or outright preferred to, Option 2 on a weighted basis across the three scenarios assessed. While we note that this value depends on a range of factors, including the assumed cost of Option 1A(4) and the assumed profile of the external funding, we currently consider this value to be at least $13.2 million based on the PACR assessment.[7]

Assuming Option 1A(4) remains preferred, the start-date for the network support contract would coincide with the expected commissioning date for the compressed-air solution in 2025/26.

Further information and next steps

This PACR represents the final formal stage in the RIT-T process.

We will update stakeholders when we consider either that both the external funding agreement and the network support agreement for Option 1A(4) are sufficiently certain, or at the point we determine there has been a material change in circumstances and that either Option 2 or Option 1A(2) should instead be progressed (i.e., when we would submit an exemption to the AER from having to reapply the RIT-T).

Assuming Option 1A(4) is progressed, the start-date for the network support contract would coincide with the expected commissioning date for the compressed-air solution in 2025/26.

Further details in relation to this project can be obtained from regulatory.consultation@transgrid.com.au.

[6] AEMC, *Transmission Planning and Investment Review*, Consultation Paper, 19 August 2021, p. 54.

[7] We consider net benefit outcomes within 5 per cent of each other to be effectively equal. In the context of the external funding, we find that it would need to be at least $13.2 million in order for Option 1A(4) to be within 5 per cent of Option 2 (whereas, in order for Option 1A(4) to have exactly the same net benefit as Option 2, $27.9 million in external funding would be required).

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1. Introduction

We have applied the Regulatory Investment Test for Transmission (RIT-T) to long-term options for maintaining reliable supply to Broken Hill. This PACR represents the final stage in the RIT-T process and follows the Project Assessment Draft Report (PADR) released on 6 October 2021.[8]

Broken Hill is located in the far west of New South Wales and is part of our south-western transmission network. It is currently supplied by a single 220 kV transmission line, 'Line X2', from Buronga which spans approximately 260 km.

When Line X2 is out of service due to planned or unplanned outage, electricity supply to Broken Hill is supported by two diesel-fired turbines (currently owned by Essential Energy[9]) to avoid involuntary load shedding. We rely on these turbines to meet the NSW Electricity Transmission Reliability and Performance Standards 2017 (the 'reliability standards') set by the NSW Energy Minister and regulated by the NSW Independent Pricing and Regulatory Tribunal (IPART). In accordance with these standards, network support provided by the turbines allows us to operate the network so as not to expect more than 10 minutes of expected unserved energy (EUE) per year at average demand.[10]

Essential Energy notified us in late-2018 of its decision to divest the turbines located at Broken Hill. Without action, this would result in the required reliability of supply to Broken Hill not being maintained, and involuntary load shedding when Line X2 is on a planned or unplanned outage. We consequently commenced a RIT-T in November 2019 to assess options for continuing to provide reliable supply to Broken Hill.

We consider this a 'reliability corrective action' under the RIT-T, as the identified need is to ensure that the externally-imposed reliability standards for Broken Hill continue to be met.

1.1. Purpose

The purpose of this PACR is to:

- identify and confirm the market benefits expected from the various options for maintaining the required reliability of supply at Broken Hill over the long-term;
- summarise the submissions received on the PADR and developments since the PADR was released and highlight how these have been taken into account in the RIT-T analysis;
- describe the options assessed under this RIT-T, including how these have been shaped as part of the consultation process;
- present the results of the updated NPV analysis for each of the credible options assessed;
- describe the key drivers of these results, and the assessment that has been undertaken to ensure the robustness of the conclusion; and
- identify the overall preferred option under the RIT-T, i.e., the option that is expected to maximise net market benefits.

[8] As outlined in the PADR released on 6 October 2021, that document replaced the initial PADR released on 11 August 2020 in light of additional guidance provided by the AER in late August 2020 regarding the treatment of non-network options in the RIT-T cost benefit assessment. All references to the 'PADR' in this PACR are to the 6 October 2021 document, unless stated otherwise.

[9] These diesel-fired turbines are currently in the process of being sold to Transgrid, as discussed further in section 2.2.4.

[10] IPART, *NSW Electricity Transmission Reliability and Performance Standard 2017*, available at: https://www.ipart.nsw.gov.au/files/sharedassets/website/shared-files/licensing-compliance-electricity-transmission-reliability/nsw-electricity-transmission-reliability-and-performance-standard-2017.pdf

Overall, a key purpose of this PACR is to provide interested stakeholders the opportunity to review the analysis and assumptions and have certainty and confidence that the preferred option has been robustly identified as optimal.

We are also releasing supplementary reports on our website to complement this PACR. Detailed cost benefit results are included as a spreadsheet appendix accompanying this report.

1.2. Further information and next steps

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

The preferred option identified in this PACR involves the continuing use of the existing diesel turbines to provide the required reliability of supply to Broken Hill in the near term, with Transgrid entering into a network support agreement with Hydrostor, to provide the longer-term reliability solution via a compressed-air energy storage facility.

Progression of this option will require both the finalisation of the in-principle external funding agreement between the Australian Renewable Energy Agency (ARENA) and Hydrostor to support development of the storage facility and the successful conclusion of a binding network support agreement between Transgrid and Hydrostor that is acceptable to the AER.

Transgrid will work closely with Hydrostor and ARENA to progress the preferred option.

We will update stakeholders when we consider either that both the external funding agreement and the network support agreement for Option 1A(4) are sufficiently certain, or at the point we determine there has been a material change in circumstances and that either Option 2 or Option 1A(2) should instead be progressed (i.e., when we would submit an exemption to the AER from having to reapply the RIT-T).

Assuming Option 1A(4) is progressed, the start-date for the network support contract would coincide with the expected commissioning date for the compressed-air solution in 2025/26.

Further details in relation to this project can be obtained from regulatory.consultation@transgrid.com.au. In the subject field, please reference ‘Broken Hill reliability project.’

2. Developments since the PADR

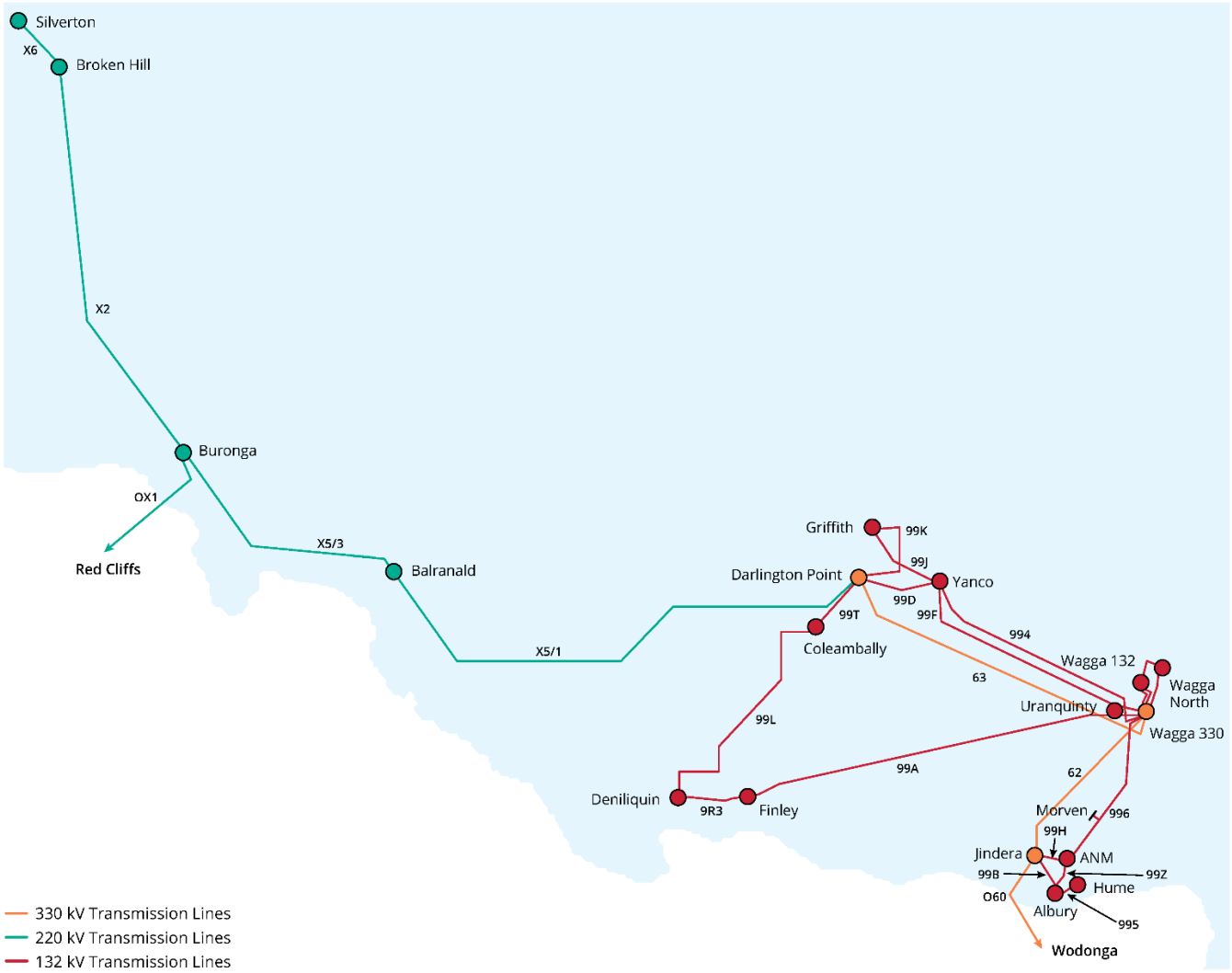
This section discusses the 'identified need' for this RIT-T before outlining a number of key developments that have occurred since the PADR was released in October 2021.

2.1. Summary of the 'identified need'

Broken Hill is part of the south-western transmission network and is supplied by a single 220 kV transmission line, Line X2, from Buronga that is around 260 km long. During a planned or unplanned outage of Line X2, Broken Hill has been supplied by Essential Energy's two back-up turbines that run on diesel fuel.

The current electricity network supplying Broken Hill is shown in Figure 2.1 below.

Figure 2.1: The current electricity network supplying Broken Hill



We have relied on the existing diesel turbines to meet our obligations under the NSW Electricity Transmission Reliability and Performance Standards 2017 (the 'reliability standards') as determined by the

NSW Independent Pricing and Regulatory Tribunal (IPART). No other source of back-up supply is currently available.[11]

Essential Energy notified us in late 2018 of its decision to divest the turbines located at Broken Hill[12] and subsequently commenced a process of enacting the divestment. In March 2021, Essential Energy confirmed that it would cease to provide network support services under the current arrangements from 10 January 2022.[13]

Without action, this will result in the required reliability of supply to Broken Hill not being maintained, and involuntary load shedding when Line X2 is on a planned or unplanned outage. We consequently commenced a RIT-T in November 2019 to assess options for continuing to provide reliable supply to Broken Hill.

We consider this a 'reliability corrective action' under the RIT-T, as the identified need is to ensure that the externally-imposed reliability standards for Broken Hill continue to be met. All of the credible options assessed in this PACR provide back-up and reliable supply to Broken Hill for the future that is consistent with the NSW reliability standard (these standards translate to approximately 7 MWh per year of EUE at Broken Hill).

In addition, some of the credible options assessed will also affect the wholesale electricity market. In particular:

- some options involve grid-connected storage that introduce new entities trading in the wholesale market, eg, dispatching into the National Electricity Market (NEM) outside of the allocation of storage needed to meet its Broken Hill network support commitments; and
- the impact on network capacity under some of the options facilitates greater uptake of renewables in surrounding Renewable Energy Zone (REZ) areas.

Both the benefits from the provision of reliable supply to Broken Hill and wider wholesale market benefits have been estimated as part of this PACR (and the earlier PADR).

2.2. Developments since the PADR was released in October 2021

A number of key developments have occurred since the PADR was released in October 2021, which impact the analysis in this RIT-T. In particular:

- AEMO released its Draft 2022 Integrated System Plan (ISP) in December 2021. The wholesale market modelling in this RIT-T has been updated to reflect the assumptions underpinning the draft 2022 ISP, and is now focused on the step-change, progressive change and hydrogen superpower scenarios;
- the proponent of Option 1A (Hydrostor) expects to secure funding from ARENA for its compressed-air energy storage solution, which we have treated as 'external funding' in this RIT-T;

[11] Both Broken Hill Solar Plant (53 MW) and Silverton Wind Farm (200 MW) provide semi-scheduled, inverter-connected generation. These generators cannot currently provide firm capacity without grid forming dispatchable generation to assist, given the intermittent nature of their generation. These generators are not currently capable of operating when Broken Hill is not connected to the rest of the network and the back-up turbines are not in-service, as currently designed and configured. This means that if neither the turbines nor Line X2 are in service, these existing renewable generators are not currently able to supply Broken Hill.

[12] Essential Energy does not have obligations to maintain the turbines in order to comply with its licencing conditions.

[13] Transgrid agreed in January 2022 to purchase the diesel turbines from Essential Energy. As a condition of the sale, Essential Energy has agreed to continue the existing arrangement under which the diesel turbines provide network support services until completion of the sale process. The sale process is discussed further in section 2.2.4.

- the battery component of Option 1D has been progressed independently by the proponent (AGL) to a stage where we now consider a smaller-scale battery to be effectively 'committed' and included in the base case for this RIT-T;
- Transgrid agreed in January 2022 to purchase the existing turbines from Essential Energy to ensure supply reliability at Broken Hill is not compromised ahead of the optimal long-term solution being able to be implemented;
- Options 1A(1), 1A(2), 1A(3) and 1A(5) have been withdrawn by their proponent (Hydrostor); and
- Options 5A(1)-(5), which involved Transgrid ownership of a compressed-air-energy storage facility built by Hydrostor are no longer considered credible options.

Each of these developments is discussed in the sections below.

2.2.1. The wholesale market modelling has been updated to reflect the draft 2022 ISP

The credible options in the PADR were assessed using a set of market modelling assumptions that were largely based on the 'central' scenario identified by AEMO for the 2020 ISP.

AEMO released the draft 2022 ISP in December 2021, based on the updated modelling assumptions that have been consulted on in the 2021 Inputs and Assumptions Report (IASR). The wholesale market modelling has consequently been updated in this PACR to:

- adopt the 2021 IASR assumptions;
- explicitly model each of the step-change, progressive change and hydrogen superpower scenarios; and
- align with the optimal development path and assumptions in the draft 2022 ISP.

Section 6.2 provides further detail on how the market modelling has been undertaken for this PACR, while Appendix C provides an overview of the market simulation exercise undertaken and the key assumptions drawn upon. A separate market modelling report prepared by EY is being released alongside this PACR.

2.2.2. The proponent of Option 1A(4) (Hydrostor) expects to secure external funding

In early 2022, the proponent of Option 1A(4) (Hydrostor) advised us that they have received Board approval from the Australian Renewable Energy Agency (ARENA) for up to $45 million for their 200MW/1500MWh compressed-air energy storage solution (ie, Option 1A(4)). ARENA has confirmed this with us. The funding negotiation is contingent on the project securing a network services agreement with Transgrid.

We have liaised with the AER in light of this development and it has indicated that evidence of ARENA's Board approval for the funding is sufficient for this to be treated as external funding in the RIT-T. This is consistent with the guidance provided by the AER in the Cost Benefit Analysis guidelines in relation to AEMO's consideration of external funding in preparing the ISP, in that the funding does not need to be fully committed to be taken into account in the analysis.[14] Prior to publishing this PACR, we sighted a letter from ARENA confirming this funding arrangement.

The ARENA funding is treated as an 'external funding contribution' under the RIT-T since it is provided by a party outside of the NEM.[15] The funding has been included in the NPV assessment as an amount that

[14] AER, *Final Decision - Guidelines to make the Integrated System Plan actionable*, August 2020, p. 23.

[15] Specifically, this funding is considered an 'external funding contribution' since it is not from a Registered Participant under the NER or any other party in their capacity as a consumer, producer or transporter of electricity in the market. See: AER, *Regulatory Investment Test for Transmission*, Application Guidelines, August 2020, pp. 56-58.

offsets the capital cost of Option 1A(4), and reflects a reduction in costs borne by those who consume, produce and transport electricity in the market in relation to this option in line with the AER RIT-T Application Guidelines.[16] The assumed timing and profile of the external funding is based on information provided by Hydrostor and by ARENA.

We have reported the key findings in absence of such funds, as well as with these funds included, in section 7 in line with the AER RIT-T Application Guidelines.[17]

2.2.3. The battery component of Option 1D is now assumed in the base case

Discussions with the proponent of Option 1D (AGL) in February 2022 confirmed that the battery component of this option is expected to proceed irrespective of the RIT-T, albeit in a smaller capacity than if Option 1D was identified as the preferred solution.[18]

In particular, in relation to the smaller capacity battery, AGL has:

- obtained all required planning consents, construction approvals and licenses;
- obtained acceptance of its environmental impact statement;
- issued a notice to proceed;
- secured firm access to land; and
- signed contracts with key suppliers.

In addition, AGL announced on 25 March 2022 that a final investment decision had been made with ARENA for its Broken Hill battery.[19]

We consider that the battery is effectively 'committed' under the RIT-T.[20] We have therefore included the smaller-scale battery development in the base case in the PACR assessment. This means that only the incremental costs associated with sizing the battery component slightly larger, to meet the need of this RIT-T, have been included in the analysis of Option 1D in this PACR. It also means that the battery is assumed to be operating as part of the wholesale market in the market modelling for all of the options.[21]

This reflects a change in approach from the PADR in light of the further discussions with AGL. Specifically, the PADR assessment included the full cost of the battery component for Option 1D in the core analysis and investigated a sensitivity under which the battery was assumed to be in the base case.

2.2.4. Transgrid is in the process of purchasing the turbines from Essential Energy

During December 2021 and January 2022, in light of Essential Energy's notification that it would withdraw its provision of network support from 10 January 2022, we made the decision to purchase the existing turbines directly from Essential Energy. The continued use of the existing diesel-fired turbines is the only way for us to meet our supply reliability obligations at Broken Hill in the immediate term.

16 AER, *Regulatory Investment Test for Transmission*, Application Guidelines, August 2020, pp. 56-58.
17 AER, *Regulatory Investment Test for Transmission*, Application Guidelines, August 2020, pp. 56-57.
18 Option 1D uses the existing 50 MW diesel-fired turbines, a 50MW/75MWh battery and 10 MW demand management.
19 https://www.agl.com.au/about-agl/media-centre/asx-and-media-releases/2022/march/agl-and-arena-lock-in-broken-hill-battery. The ARENA funding for this battery is in support of the lower capacity investment, and so has not been applied as an external funding contribution for Option 1D.
20 As defined in the glossary of the RIT-T.
21 We have not undertaken wholesale market modelling for Option 1D, since it would only reflect the incremental change in wholesale market outcomes due to the modest increase in the size of the battery under Option 1D compared with the committed battery size, and so is not expected to be material to the RIT-T outcome.

Further, based on the findings of the PADR, we consider this purchase to be a 'no regrets' decision, as the continued use of the existing turbines, at least in the near-term, was found to be a common feature across all three of the top-ranked options in the PADR assessment.

We formally signed an agreement with Essential Energy on 31 January 2022 to purchase the turbines for $15 million and the sale is expected to be completed by 31 May 2022 (the agreement features a number of conditions precedent). Essential Energy has agreed, as a condition of the sale, to continue to provide network support until the sale process has been completed.

We consider the decision to purchase the turbines from Essential Energy to be incidental to this RIT-T assessment. In particular, the conclusion of this RIT-T assessment will occur prior to the completion of the sale process and has confirmed that the turbines are part of the preferred long-term reliability solution for Broken Hill.

As a consequence, we do not consider that our purchase of the turbines changes the high-level assessment framework adopted for this RIT-T. Specifically, we consider it prudent to continue to have the RIT-T assessment focus on the Essential Energy divestment process, i.e., the same point of reference as for the PADR assessment, so that the identification of the preferred option is not pre-empted by our decision to purchase the turbines.

However, we have updated the assessment in four ways in light of the process we are currently going through to purchase the turbines. Namely:

- The assessment now focuses on one base case ('base case II' from the PADR[22]) and discontinues assessing the other base case ('base case I' from the PADR[23]) – Essential Energy has confirmed that there was no party from outside of the NEM that participated in the recent divestment process for the existing turbines (which was the defining feature of base case I in the PADR).
- The decision to purchase the turbines from Essential Energy has allowed us to physically inspect the turbines and refine the estimates of the expected refurbishment costs and refurbishment timing for Option 2, which have been reflected in the PACR assessment – specifically, we engaged Aurecon to undertake this review, which concluded in February 2022, and found that turbine refurbishment costs would be higher than those estimated for the PADR.
- For the Option 1A variants, we are now a proponent for the continued ownership and operation of the turbines, which form an interim component of these options. We have therefore updated the description of the Option 1A variants in the PACR assessment to reflect that they would be provided as a combination of both Transgrid ownership of the turbines as an interim measure and non-network proponent ownership of the compressed-air storage solution.[24] We note that this has no impact on the outcome of the NPV assessment but represents a realistic approach to delivering the combined solution.
    - For Option 1D, which involves the continued, long-term operation of the diesel-fired turbines together with other solution components, we have assumed that the proponent of that option would purchase the turbines from Transgrid in order to provide the solution.

[22] Base case II is defined in the PADR as where the existing turbines are not able to be sold via the divestment process and Essential Energy decommissions them in the future.
[23] Base case I is defined in the PADR as where the existing turbines are sold to a party outside of the NEM, e.g., a mine that is not connected to the NEM.
[24] In the PADR assessment, it was assumed that the non-network proponent would purchase the turbines from Essential Energy and operate them for this interim period.

- The existing turbines also now form the interim component of Option 1F, Option 5G, Option 3 and Option 4.[25] We would operate the turbines in the short-term under these options to maintain compliance with the reliability standards prior to the primary components of these options being commissioned.

2.2.5. Hydrostor has withdrawn Option 1A(1), Option 1A(2), Option 1A(3) and Option 1A(5)

The number of 'Option 1A' variants included in the PADR reflected the on-going discussions and analysis with Hydrostor at that point in time. As outlined above, Hydrostor has now secured a significant external funding contribution for Option 1A(4) and has subsequently decided to withdraw all other Option 1A variants, i.e., Option 1A(1), Option 1A(2), Option 1A(3) and Option 1A(5).

While Option 1A(2) has been removed from the core analysis, it has been included as a sensitivity to demonstrate the impact on the PACR conclusion if Hydrostor were to later decide to provide the network support via a smaller-sized option (which we have assumed for the purpose of the PACR analysis may not receive ARENA funding) (see section 7.5.7).

2.2.6. Options 5A(1)-(5) are no longer considered to be credible options

The PADR assessment included Option 5A(1), Option 5A(2), Option 5A(3), Option 5A(4) and Option 5A(5), which were identical to Options 1A(1)-(5) except that Transgrid was assumed to own the compressed-air-energy storage facility, wholly or partially. These options are no longer considered credible options in light of Hydrostor now focusing on the provision of one non-network option – Option 1A(4).

[25] In the PADR assessment, it was assumed that interim network support under these options would be provided under an alternative network support agreement.

3. Consultation on the PADR

The PADR was released in October 2021 and we subsequently received submissions from four parties.

While submissions covered a range of topics, there were four broad topics that were most commented on:

- support for the use of a compressed-air energy storage solution;
- concern with the reliability of options involving diesel turbines over the long-term, and inconsistency with clean energy goals;
- interaction with potential new mining loads at Broken Hill; and
- the need for consistency with the latest ISP.

In addition, we have held a number of bilateral meetings with the non-network proponents in order to more fully understand how proposed solutions are expected to be able to assist with meeting the identified need. These discussions have played a pivotal role in being able to refine the assessment in this PACR and we thank all parties for their time and effort to-date.

The key matters raised in submissions relevant to the RIT-T assessment are summarised in the following subsections, together with our responses and how the matters raised have been reflected in the PACR assessment. Appendix E provides a summary of all points raised as part of consultation on the PADR.

3.1. Use of a compressed-air energy storage solution

The Broken Hill City Council commented on a range of benefits expected from a compressed-air energy storage solution, including:[26]

- repurposing of an end of life mine located in Broken Hill;
- providing new employment and skills opportunities;
- supporting sustained economic growth with new sources of revenue; and
- supporting more renewable energy generation in the region with better economic returns.

Hydrostor, Energy Estate and the Broken Hill City Council emphasised an estimate from ACIL Allen that compressed-air energy storage can deliver investment in the order of $500 million in the Broken Hill region, creating many direct and indirect jobs and making a total contribution of more than $1 billion to the local economy for over 40 years of operational lifetime.[27]

While we note these expected real sources of benefit, they are not able to be captured in the RIT-T analysis due to it being a cost-benefit assessment focussed on ‘all those who produce, consume and transport electricity in the market’ and the above types of benefits are considered ‘externalities’ under the RIT-T. The exception to this relates to impact on renewable generation in the area, which has been captured in the wholesale market modelling undertaken in this PACR.

Energy Estate stated that these solutions will have a very significant positive impact on the marginal loss factors (MLF) and curtailment issues facing the wind and solar farms currently operating in Broken Hill. They also submitted that the addition of a large-scale energy storage solution of this type at Broken Hill is

[26] Broken Hill City Council, p. 3
[27] Hydrostor, p. 2, Broken Hill City Council, p. 3 & Energy Estate, p. 2

also forecast to benefit many other generators in the West Murray Zone (and note that ACIL Allen has confirmed this in analysis undertaken for them)).[28]

The market modelling undertaken for this PADR does not assess how much MLFs will change and we note it depends largely on whether new solar farms locate in the region as a result of the compressed-air energy solution. We agree with Energy Estate's position though that the MLFs will likely increase for these generators.

3.2. Options involving diesel turbines over the long-term

The Broken Hill City Council submitted that there is no detailed or convincing justification of the ability of the diesel-fired turbines to function successfully and reliably in the long-term in the PADR.[29] Similarly, Hydrostor submitted that the diesel turbines, given the age and operating history, have not been adequately demonstrated to be reliable as a long-term solution.[30]

Hydrostor stated that, without clear independent verification of actual turbine condition, it can only be assumed that the condition of the diesel turbines is commensurate with their age and that they would not be suited for an application requiring prolonged or regular operation. Hydrostor stated that the PADR does not describe what changes will be made to the existing diesel turbines to mitigate their deteriorated condition to provide for increased operation in the future.[31]

Energy Estate stated that they find it surprising that the Aurecon report referred to in the revised PADR concluded that the turbines will be able to continue operating for decades based on a desktop basis (i.e., without being able to physically inspect them). They also stated that the PADR has assumed that no material expenditure will be required or prudent in order to achieve this stated goal.[32]

Since the PADR was released, and aided by the procurement process we are currently undergoing (as outlined in section 2.2.4), we have been able to have Aurecon more thoroughly assess the current condition of the turbines, including through physical inspection, and the required refurbishment work (and cost) in order to ensure they can function satisfactorily to meet the identified need. This more in-depth assessment has resulted in the refurbishment costs increasing since the PADR.

Overall, the updated Aurecon review has given us confidence that the existing turbines are able to meet the reliability requirements at Broken Hill as part of Option 2.

The Aurecon report provides details of, and costs for, the refurbishments that are required to the existing diesel turbines to mitigate their condition and provide for increased operation in the future.

A range of parties commented that the prolonged use of diesel generators is inconsistent with:[33]

- NSW Government's Electricity Infrastructure Roadmap;
- NSW Government target of 50 per cent reduction by 2030 and net zero by 2050;
- Commonwealth Government's net zero policy by 2050 and a 35 per cent reduction in emissions by 2030;

[28] Energy Estate, p. 2.
[29] Broken Hill City Council, p. 2.
[30] Hydrostor, p. 5 .
[31] Hydrostor, p. 5 .
[32] Energy Estate, p. 3.
[33] Broken Hill City Council, pp. 1-2, Hydrostor, p. 3, Energy Estate, p. 2

- the AER's commitment to the newly launched international Regulatory Energy Transition Accelerator;
- the Broken Hill City Council's Sustainability Strategy;
- the Broken Hill City Council's Renewable Energy Action Plan (REAP);
- the direction of energy markets in NSW and across Australia; and
- Transgrid's corporate vision.

Hydrostor further state that the AER requires Network Service Providers to take into account feedback from the community and stakeholders as part of the RIT-T process and that the feedback from the Broken Hill community and stakeholders is clear that Transgrid should not progress with the acquisition of the diesel generators and, instead, select the highest-ranking clean energy option in the PADR.[34]

We highlighted in the PADR how the long-term adoption of diesel turbines to meet reliability in the Broken Hill area sat uncomfortably with the broader policy goals of lowering emissions and supporting the energy sector transition. Notwithstanding, none of the instruments listed above preclude the long-term use of the existing turbines as being identified as the preferred option under the RIT-T. Further, the regulatory framework does not permit Transgrid to unilaterally decide to exclude this option from the RIT-T assessment.

However, we note that the external funding contribution provided by ARENA since the PADR has assisted in the PACR concluding that the turbines are no longer the preferred option in this PACR (subject to there being no 'material change in circumstances', as outlined in section 8). The use of external funding to bridge the gap between the RIT-T assessment and the achievement of broader policy objectives is consistent with the RIT-T framework.

3.3. Interaction with potential new mining loads at Broken Hill

The Broken Hill City Council submitted that two new mines are currently in the latter stages of development and represent the future of the mining industry in the Broken Hill region (Cobalt Blue and Hawsons Iron). They state that these mines cannot be adequately supported by the diesel-fired turbines and believe this aspect of the PADR analysis has not been adequately considered.[35]

Similarly, Hydrostor submitted that they are aware of new mining loads being progressed in the region (referring to the Cobalt Blue and Hawsons Iron mines) and that these developments will be hindered by not having access to a long-term, cost effective, predictable, and reliable supply of electricity.[36]

We have engaged further with these prospective mines since the PADR and do not consider that either meet the criteria for 'committed' or 'anticipated' status under the RIT-T at this stage (and so they do not feature in the core analysis presented in this PACR). We have however considered whether they are likely to change the conclusion of the PACR if they do go ahead by way of a sensitivity (see section 7.5.3). We find that Option 1A(4) would be able to accommodate the increase in mining load without the need to incur additional option costs. This finding is in line with the conclusion of this RIT-T that Option 1A(4) is preferred, subject to there being no 'material change in circumstances'.

[34] Hydrostor, p. 3 .
[35] Broken Hill City Council, p. 2.
[36] Hydrostor, p. 6.

3.4. Consistency with the latest ISP

A number of parties commented on how the revised PADR did not update the assumptions and scenarios used to be consistent with the draft 2022 ISP (and instead continues to use the market modelling from the initial PADR, which reflected the 2020 ISP).[37]

The core market modelling for the revised PADR was not updated from the initial PADR as the intention of the revised PADR was to show the results of the analysis *if the revised AER guidance had been applied at the time of the initial PADR*. The market modelling in this PACR has been updated to align with the draft 2022 ISP (see section 2.2.1).

Hydrostor noted that, since the completion of the EY report, the NSW Government has released its Energy Roadmap and that this should be reflected in the modelling.[38]

We note that the NSW Energy Roadmap is reflected in the draft 2022 ISP. The market modelling for this RIT-T has been updated based on the 2022 ISP assumptions and therefore also takes into account the NSW Energy Roadmap.

[37] Hydrostor, p. 5 & Energy Estate, p. 3
[38] Hydrostor, p. 5.

4. Five types of options are assessed

Stakeholder consultation over the course of this RIT-T has assisted greatly with developing and refining the credible options considered. We thank all parties for their time and contributions.

Specifically, consultation with third parties has enabled this PACR to assess the following five types of credible options:

- Option 1: three different non-network opex solutions, predominantly provided by third parties:
  - Option 1A(4) (proposed by Hydrostor): a 200MW/1500MWh compressed-air energy storage solution .
    - > This option requires continued use of diesel-fired turbines in the short-term, prior to its delivery and commissioning. It is now assumed that Transgrid would own and operate the turbines for this interim period;
  - Option 1D (proposed by AGL): use of the existing 50 MW diesel-fired turbines acquired by the proponent (and provided to Transgrid as a service), 50MW/75MWh battery and 10 MW demand management; and
  - Option 1F: 100MW/800MWh liquid-air energy storage.
- Option 2: Transgrid acquiring the existing turbines from Essential Energy and refurbishing them as required over the long-term.
  - The costs of this option have been updated since the PADR, based on more accurate information on both the acquisition price and subsequent refurbishment costs;
- Option 3: establishing new diesel-fired turbines at Broken Hill;
- Option 4: building a second single circuit 220 kV transmission line from Buronga to Broken Hill; and
- Option 5G: 50MW/275MWh thermal energy storage, to be wholly or partially owned by Transgrid.

Aside from Option 1D and Option 2, which require the on-going use of the existing diesel-fired turbines, all options require continued use of the diesel-fired turbines in the short-term to continue to meet the reliability standards at Broken Hill, prior to the delivery and commissioning of the main option components.[39] It is assumed that Transgrid would own and operate the existing turbines for this interim period.

The timing of all options assessed in the PACR has been updated slightly from the PADR to reflect the passage of time since that analysis and further analysis by Transgrid's project development team regarding realistic construction timetables. This has resulted in all options, other than Option 3 and Option 4, being assumed to be delivered one year later than in the PADR assessment. Options 3 and 4 are now assumed to be delivered four years later than in the PADR assessment.

All options reduce EUE to the amount required under the IPART reliability standard, which translates to approximately 7 MWh per year, on the assumption of no future spot load development. Option 4 provides an additional level of reliability due to the second transmission line and is assessed to reduce EUE to effectively zero (again on the assumption of no future spot load development).

Option 3 would also provide additional reliability over the IPART reliability standard, on account of the new turbines being able to start-up faster than required under the reliability standard. However, this has not

[39] In the PADR assessment, it was assumed that interim network support under options 3, 4 and 5G would be provided under an alternative network support agreement.

been modelled as the requisite technical parameters for these turbines is not known. The PACR assessment therefore assumes that Option 3 provides the same level of reliability as the other options (with the exception of Option 4), which is not expected to be a material assumption in terms of identifying the preferred option due to the materially higher cost of this option compared with the preferred option.

Aside from updated refurbishment costs and operating expenditure associated with Transgrid operating the diesel-fired turbines in the short term, the three non-network solutions provided by third parties, along with Option 5G, have been assessed using the same information (including costs) as provided by parties for the PADR, i.e., in response to our March 2021 requests for clarification following the new AER guidance, and in subsequent engagement. The proponents of those solutions have confirmed that the information remains correct for the PACR. In order to maintain confidentiality of commercial-in-confidence information in submissions, these costs, and cost structures, have not been presented in this PACR.

Where an option involves continued use of the existing turbines, we have assumed the need for future investment in new turbines, reflecting the age and condition of the existing turbines at Broken Hill.[40] We have assumed that the cost of this future investment is the same, in real terms, as the cost of establishing new turbines at Broken Hill now (i.e., as outlined below for Option 3) and occurs in 2044. This reflects an independent review of the asset condition and expected life of the existing turbines commissioned by Transgrid as part of the PACR.

We have completed a holistic technical review of the compressed-air storage options considered in this PACR, and are confident that the solution is technically feasible. This review has been supported by an independent technical assurance report from Aurecon.

The remainder of this section provides further detail on each of the five types of credible options assessed in this PACR.

4.1. Non-network solutions predominantly provided by third parties – Option 1A(4), Option 1D and Option 1F

These options involve a network support arrangement (or arrangements) to provide back-up supply for Broken Hill to meet reliability standards and satisfy the identified need. These options are considered non-network options where these services would be provided by a third-party by way of a network support contract.

Three parties have offered to provide these services and a range of technologies have been proposed:

- Option 1A(4) (proposed by Hydrostor): a 200MW/1500MWh compressed-air energy storage solution.
  - This option requires continued use of diesel-fired turbines in the short-term, prior to its delivery and commissioning. It is now assumed that Transgrid would own and operate the turbines for this interim period;
- Option 1D (proposed by AGL): use of the existing 50 MW diesel-fired turbines acquired by the proponent (and provided to Transgrid as a service), 50MW/75MWh battery and 10 MW demand management; and
- Option 1F: 100MW/800MWh liquid-air energy storage.

[40] The existing turbines at Broken Hill were commissioned in the late 1980s and were not new assets at the time.

- This option also requires the continued use of diesel-fired turbines in the short-term, prior to delivery and commissioning. It is assumed that Transgrid would own and operate the turbines for this interim period.

The options put forward also reflect a range of sized solutions, with two (Options 1A(4) and Option 1F) enabling trade in the wholesale market. These two options are expected to provide wholesale market benefits in addition to the required level of reliability at Broken Hill and the impact they are expected to have on the wholesale market has been modelled by EY (as outlined in section 6 below).

Where these options relate to new facilities, the full cost of these new investments (and the associated operating costs) has been reflected in the cost benefit assessment (as a 'cost to other parties'), with the proposed network support payment treated as a wealth transfer between the proponent and us, in-line with the AER August 2020 guidance.

As covered in section 2.2.2, Hydrostor, as the proponent for Option 1A(4), expects to secure external funding from ARENA, which has been taken into account in the NPV assessment as it reduces the costs that are borne by parties in the NEM.

Further, as discussed in section 2.2.3, the battery component of Option 1D is now assumed to be an effectively committed project and has therefore been reflected in the base case, with only the incremental costs associated with investment in a larger-scale battery to meet the network support requirement included in the NPV assessment of this option.

Some of the non-network solutions will require associated network investment. For example, there is a need to upgrade existing switchbays for Option 1A(4), whilst new switchbays are required for Option 1F and Option 5G. In addition, fault level upgrades would be required for Option 1A(4) and Option 1F to address fault level limitations associated with the connection of these options. We have reflected the cost and timing of these various investments in the NPV assessment.

We note that Transgrid's decision to purchase the turbines from Essential Energy has resulted in a change to options that involve the use of the turbines in the short-term, i.e.;

- under Option 1A(4), the proponent is no longer assumed to purchase the turbines to use them to provide the interim network support at Broken Hill, since Transgrid would now be a proponent for continued ownership for the turbines for this interim period. This change in the party assumed to own the turbines for the interim period does not affect the outcome of the NPV assessment; and
- under Option 1F, Transgrid would now own and operate the existing turbines until the liquid-air energy storage is commissioned. This represents a change from the revised PADR, where it was assumed that interim network support would be provided under an alternative agreement.
    - As a result, expenditure associated with continuing to operate the existing turbines in the short term has been included in the PACR assessment, replacing the expenditure associated with the alternative interim network support agreement previously assumed.

For the option involving the continued, long-term use of the turbines (Option 1D), we continue to assume that the proponent purchases the turbines (since they form part of their long-term portfolio of solutions).

4.2. Acquiring the existing turbines from Essential Energy – Option 2

Option 2 involves the acquisition by Transgrid of the existing turbines at Broken Hill from Essential Energy, and the refurbishment of the turbines as needed in order to provide long-term reliability of supply to Broken Hill.

This option therefore assumes that the existing turbines become directly owned by us, rather than being purchased by a third party who may then use them to offer network support services.

As outlined in section 2.2.4, we are currently in the process of purchasing the turbines from Essential Energy for $15 million.[41] The analysis in this PACR has therefore been updated to reflect the actual purchase cost agreed with Essential Energy (which is materially below the estimated purchase cost in the PADR which was based on information provided by Essential Energy at that time).

The AER guidance requires that the amount paid by Transgrid to acquire the existing turbines from Essential Energy be offset by the benefit Essential Energy receives from the sale, i.e., resulting in a net direct cost of zero associated with the purchase of the turbines under Option 2. However, we would incur costs to refurbish the turbines under this option, as well as incurring the operating costs (including fuel costs) associated with the times they are required for network support.

As outlined in section 2.2.4, we have been able to refine the expected refurbishment costs for the turbines since the PADR as part of purchasing them from Essential Energy. This updates the costs and timing of refurbishing the turbines provided by Essential Energy for the PADR.

This option also assumes that the existing turbines need to be replaced by new turbines in 2044. This assumption has been based on information provided by Aurecon and is not considered material to the assessment.[42]

Option 2 would not require any associated network investment (relating to switchbays or fault level upgrades).

4.3. Establishing new turbines at Broken Hill – Option 3

Option 3 involves the commissioning of new turbines at Broken Hill. Potential new generators may be able to utilise the latest diesel-fired turbine technologies, which could improve fuel efficiency and response times (compared to the existing turbines).

We engaged Aurecon to develop generic costs and technical parameters for Option 3. These new turbines are assumed to involve $78 million in capital costs upfront, as well as ongoing operating costs of approximately $1.6 million per year. The estimated timing of this option has been updated based on further analysis, and it is now estimated that they would take four years to install and that commissioning would occur in 2026/27.

[41] As discussed in section 2.2.4, Transgrid's decision to purchase the turbines is not intended to pre-empt the outcome of this RIT-T and so this option is considered alongside all other options in the PACR.

[42] Specifically, the assumed replacement of the existing turbines in 2044 is not considered material to the assessment, compared to assuming they last the entire period, i.e., if we instead assumed they lasted the entire period, it would not change the key findings of the PACR.

There would be upfront network capital costs of $11 million associated with fault level upgrades, which is assumed to require ongoing operating costs of approximately $110,000 per year.

The new turbines commissioned under Option 3 will enable dispatch to the wholesale market during times of high wholesale market prices. The impact they are expected to have on the wholesale market has been modelled by EY (as outlined in section 6 below).

4.4. Establishing a second single circuit 220 kV transmission line – Option 4

Option 4 involves a new single circuit 220 kV transmission line from Buronga to Broken Hill to improve the reliability of the supply to Broken Hill.

The scope of Option 4 involves:

- constructing a second circuit alongside Line X2 between Broken Hill and Buronga;
- constructing 220 kV line switchbays at Broken Hill and Buronga; and
- installation of line shunt reactors at Broken Hill and Buronga.

The capital expenditure estimate for Option 4 is $474 million, with project delivery occurring over five years and commissioning in 2027/28.[43] Annual operating costs are estimated to be approximately $4.7 million.

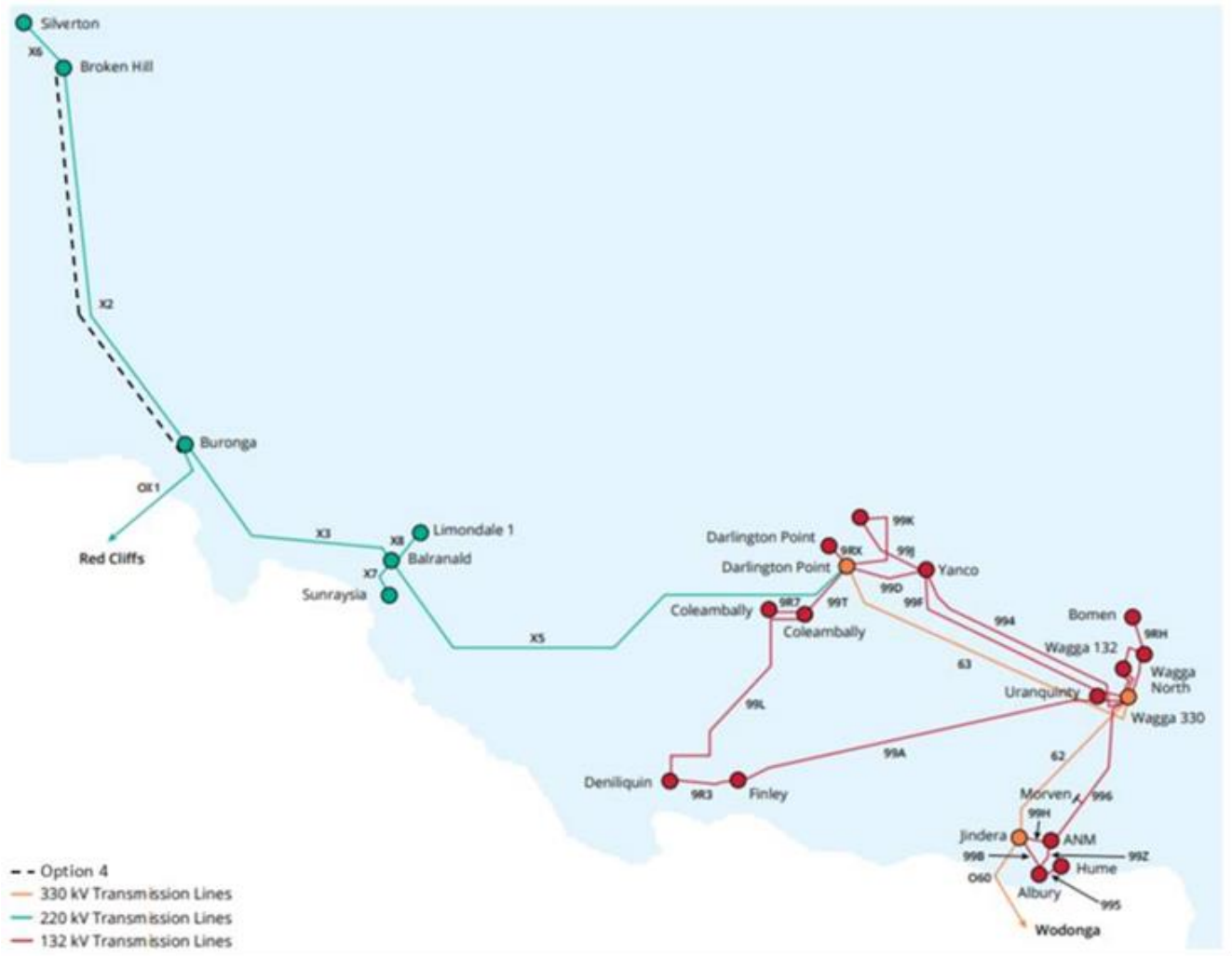
The cost estimates and rates are based on nearby projects over similar terrain for which we have recently sourced market costs (eg, EnergyConnect).

While Option 4 is significantly more expensive than the other options, it has been included in the PACR assessment since it is considered technically feasible and serves as a source of comparison for the other options. It also provides associated market benefits through its impact on the development of nearby REZs.

We have included a network diagram below for Option 4, which shows the existing network configuration, as well as the works and new elements (with a black dashed line).

[43] This has been updated since the PADR assessment, where it had been assumed that the new line could be delivered in 36 months, based on further analysis by Transgrid.

Figure 4.1: Network diagram for Option 4



4.5. Network (or shared) ownership of network support technologies – Option 5G

Option 5G involves 50MW/275MWh thermal energy storage delivered through ownership by Transgrid as a network asset, or via a shared ownership model.

The proponent of Option 5G has requested confidentiality and so this PACR does not outline the option in detail.

The full cost of the new investment in thermal energy storage (and the associated operating costs) have been included in the cost benefit assessment.

Option 5G is expected to provide wholesale market benefits in addition to the required level of reliability at Broken Hill and the impact it is expected to have on the wholesale market has been modelled by EY (as outlined in section 6 below).

4.6. Options considered but not progressed

The table below summarises the options that have been considered over the course of this RIT-T but have not been progressed.

Table 4-2: Options considered but not progressed over the course of this RIT-T

Option	Reason(s) for not progressing
Option 1C/5C, Option 5B and Option 1E/5E from the PADR.[44]	The proponents of these options have withdrawn their offers since the PADR.
Option 1A(1), Option 1A(2), Option 1A(3) and Option 1A(5) from the PADR.	The number of Option 1A variants included in the PADR reflected the on-going discussions and analysis with the proponent (Hydrostor) at that time. These discussions have subsequently become more focused on the core option included in the PACR analysis (i.e., Option 1A(4)). Hydrostor has subsequently decided to progress Option 1A(4) and has withdrawn Option 1A(1), Option 1A(2), Option 1A(3) and Option 1A(5). While Option 1A(2) has been removed from the core analysis, it has been included as a sensitivity – see section 7.5.7.
Option 5A(1), Option 5A(2), Option 5A(3), Option 5A(4) & Option 5A(5) from the PADR.	Options 5A(1)-(5) were five different sized options that mirrored the Option 1A(1)-(5) solutions in the PADR, from Hydrostor, but involved either shared ownership or ownership by Transgrid. As discussed in section 2.2.6, it is no longer considered a credible option for Transgrid to own these solutions, either wholly or partially, as the proponent (Hydrostor) is now pursuing Option 1A(4) as a non-network option only.
Double circuit 330 kV line to Mount Piper	Costs estimated are significantly higher than Option 4 due to the distance, without any additional market benefits. Accordingly, these two options are not considered to be commercially feasible.
HVDC link to Mount Piper	

[44] Option 1C/5C involved a 73MW/292MWh battery, Option 5B involved a 62.5MW/250MWh battery and Option 1E/5E involved a 222MW/444MWh battery.

5. Ensuring the robustness of the analysis

The investments considered as part of this RIT-T involve long-lived assets, and it is important that the recommended preferred option does not depend on a narrow view of future outcomes, given that the future is inherently uncertain.

Uncertainty is captured under the RIT-T framework through the use of reasonable scenarios, which reflect different assumptions about future market development, and other factors that are expected to affect the relative market benefits of the options being considered. The adoption of different scenarios tests the robustness of the RIT-T assessment to different assumptions about how the energy sector may develop in the future.

The robustness of the outcome is also investigated through the use of sensitivity analysis in relation to key input assumptions. We have identified the key factors driving the outcome of this RIT-T and sought to identify the 'threshold value' for these factors, beyond which the outcome of the analysis would change.

5.1. The assessment considers three 'reasonable scenarios'

The RIT-T is focused on identifying the top ranked credible option in terms of expected net benefits. However, uncertainty exists in terms of estimating future inputs and variables (termed future 'states of the world').

To deal with this uncertainty, the NER requires that costs and market benefits for each credible option are estimated under reasonable scenarios and then weighted based on the likelihood of each scenario to determine a weighted ('expected') net benefit. It is this 'expected' net benefit that is used to rank credible options and identify the preferred option.

The credible options have been assessed under three scenarios as part of this PACR assessment, which differ in terms of the key drivers of the estimated net market benefits.

The three alternative scenarios are characterised as follows:

- a 'low net economic benefits' scenario, involving a number of assumptions that gives a lower bound and conservative estimate of net present value of net economic benefits;
- a 'central' scenario which consists of assumptions that reflect our central set of variable estimates that provides the most likely scenario; and
- a 'high net economic benefits' scenario that reflects a set of assumptions which have been selected to investigate an upper bound of net economic benefits.

The table below summarises the specific key variables that influence the net benefits of the options under each of the scenarios considered.

Table 5-3: Summary of scenarios

Variable	Central	Low net economic benefits	High net economic benefits
Network capital costs	Base estimate	Base estimate + 25%	Base estimate - 25%
Non-network costs	Base estimate	Base estimate + 25%	Base estimate - 25%
Broken Hill demand	Based on POE50 demand forecast	Based on POE90 demand forecast	Based on POE10 demand forecast
Wholesale market benefits estimated	EY estimated based on the step-change 2022 ISP scenario	EY estimated based on the progressive change 2022 ISP scenario	EY estimated based on the hydrogen superpower 2022 ISP scenario
VCR	$37.78/kWh	$26.45/kWh	$49.12/kWh
Discount rate	5.50%	7.50%	1.96%

The underlying demand forecasts at Broken Hill remain the same as those in the PADR and align with our 2021 Transmission Annual Planning Report. These demand forecasts exclude the impact of any future mining load development. We have considered the impact of new mining load as a sensitivity (see section 7.5.8).

5.2. Weighting the reasonable scenarios

We have weighted each of the scenarios for this RIT-T based on the draft 2022 ISP weightings for the underlying wholesale market scenarios. Specifically, we have given each scenario a weighting based on the proportion its weighting in the draft 2022 ISP makes up of the cumulative 96 per cent given to these three scenarios, i.e.:[45]

- 52 per cent to central scenario (based on the step-change scenario in the ISP);
- 30 per cent to the low benefits scenario (based on the progressive change scenario in the ISP); and
- 18 per cent to the high benefits scenario (based on the hydrogen superpower scenario in the ISP).

While these weights have been applied to weight the estimated market benefits and identify the preferred option across scenarios (illustrated in section 7), we have also carefully considered the results in each scenario in section 7. We have also undertaken a sensitivity using the weighting across the scenarios adopted in the PADR.

5.3. Sensitivity analysis

In addition to the scenario analysis, we have also considered the robustness of the outcome of the cost benefit analysis through undertaking a range of sensitivity testing.

[45] We note also that these weights align with the weights AEMO have recommended be applied to the VNI West RIT-T (where the same three scenarios are to be considered) in the draft 2022 ISP released in December 2021 – see: AEMO, *Draft 2022 Integrated System Plan*, December 2021, p. 69.

The range of factors tested as part of the sensitivity analysis in this PACR are:

- an increase in the capacity of the 330 kV transmission system west of Wagga Wagga, consistent with the outcome of the concurrent 'improving stability in south-western NSW' RIT-T;
- the existing turbines in Option 2 being retro-fitted to be able to dispatch to the NEM and generate wholesale market benefits;
- assuming new mining spot load development in the Broken Hill area;
- alternate commercial discount rate assumptions;
- different scenario weightings (i.e., those adopted in the PADR);
- the assumed profile of the external ARENA funding; and
- a decision by Hydrostor to revert to a smaller-sized solution (i.e., Option 1A(2) from the PADR), with no ARENA funding.

The additional sensitivities investigated as part of the PADR have not been repeated in the PACR as they are now either considered not relevant, or were found to exhibit a lack of sensitivity in the PADR assessment.

The results of the sensitivity tests are discussed in section 7.5.

In addition, as part of the PACR analysis we have also identified the key factors driving the outcome of this RIT-T and sought to identify the 'threshold value' for key variables beyond which the outcome of the analysis would change.

6. Estimating the market benefits

The key benefit expected from the options is avoided involuntary load shedding at Broken Hill. In addition, for some of the options, there are also expected to be benefits from anticipated changes in the wholesale market outcomes going forward.

The RIT-T requires categories of market benefits to be calculated by comparing the 'state of the world' in the base case where no action is undertaken, with the 'state of the world' with each of the credible options in place, separately. The 'state of the world' is essentially a description of the National Electricity Market (NEM) outcomes expected in each case, and includes the type, quantity and timing of future generation investment as well as unrelated future transmission investment (e.g., that is required to connect REZ across the NEM).

This section outlines how each of the broad categories of market benefit have been estimated. It first outlines the base case that have been modelled, as well as the three broad states of the world and a high-level description of the modelling undertaken for each.

6.1. The base case for assessment

The RIT-T requires the assessment to compare the costs and benefits of each option to a base case 'do nothing' option. The base case is the (hypothetical) projected case if no action is taken, ie:[46]

> "The base case is where the RIT-T proponent does not implement a credible option to meet the identified need, but rather continues its 'BAU activities'. 'BAU activities' are ongoing, economically prudent activities that occur in absence of a credible option being implemented"

The base case has increasing levels of unserved energy at Broken Hill when Line X2 is out of service. While we would never plan for this situation to eventuate, and have initiated this RIT-T to avoid this outcome, the RIT-T framework requires the credible options to be assessed against a common base case representing a state of the world where action is not taken to address the long-term need.

For this RIT-T, an important feature of the base case is the assumption regarding the future of the existing turbines at Broken Hill in the absence of an option. Importantly, the 'do nothing' base case for this RIT-T should not assume that these turbines continue to operate in the same manner as they have done to-date.

The PADR assessment modelled two alternate base cases, which reflected the uncertainty at the time regarding the outcome of the Essential Energy divestment process for the existing turbines. Specifically, the PADR modelled all credible options against the following two base cases:

- Base case I – the existing turbines are sold to a party outside of the NEM, e.g., a mine situated outside of the NEM; and
- Base Case II – the existing turbines are not sold and Essential Energy decommissions them in the future.

As discussed in section 2.2.4, Transgrid is in the process of purchasing the turbines from Essential Energy. Essential Energy has confirmed that there was no party from outside of the NEM that participated in the divestment process for the existing turbines (which was the defining feature of base case I in the PADR).

[46] AER, *Regulatory Investment Test for Transmission Application Guidelines,* August 2020, p. 21.

The assessment in this PACR therefore focuses on a single base case ('base case II' from the PADR) and discontinues assessing the other base case ('base case I' from the PADR).

Base case II reflects a circumstance where the only willing buyer for the turbines is either Transgrid, or a third party, in the context of continuing to provide network support at Broken Hill. Where there are no parties interested in buying the existing turbines in the absence of a network support agreement, in the base case Essential Energy would need to incur costs to decommission the existing turbines in the future. The PADR assumed an indicative decommissioning cost in the core analysis. For the PACR analysis, we have had Aurecon develop a refined estimate of decommissioning costs as part of the additional work they have done assessing the condition of the existing turbines and the likely refurbishment costs (as outlined in section 2.2.4).[47]

6.2. Overview of the market modelling undertaken

There are three broad states of the world that have been modelled as part of this PACR. These can be summarised as:

1. Line X2 is in-service meaning electricity demand at Broken Hill can be met from supply anywhere in the NEM and any new technologies at Broken Hill able to trade in the wholesale market can do so;
2. Line X2 is out-of-service meaning Broken Hill is no longer connected to the NEM and needs to source supply from its own grid (or face unserved energy); and
3. Line X2 is out-of-service but Broken Hill remains connected to the NEM via a new line (i.e., Option 4).

We engaged EY to undertake wholesale market modelling to assess the market benefits associated with those credible options that are expected to have an impact on the wholesale market.

This market modelling exercise captures:

- what happens in the NEM and Broken Hill under the first and third states above; and
- what happens in the NEM, outside of Broken Hill, under the second state above.

The costs and information provided by proponents and our internal analysis are used to model what happens at Broken Hill under the second state above, i.e., the cost to service Broken Hill demand when Line X2 is out of service and there is no second line connecting Broken Hill to the NEM.

6.3. Avoided involuntary load shedding

We have run system studies to estimate the EUE at Broken Hill under the base case and each of the credible options. This involved assessing the existing load at Broken Hill, expected growth, the condition of Line X2, outage rates and outage durations.

Specifically, for options involving energy storage as the sole backup supply, additional parameters have been assessed to estimate EUE. Both the size of the energy storage facility and the output of the Broken Hill renewable generators are considered to meet the reliability standard. As an outage of Line X2 can occur at any time, the energy storage system must maintain a minimum state of charge (estimated to be 250 MWh) in anticipation of an outage to supply the Broken Hill islanded load together with variable renewable generation. For options involving new turbines, the amount of EUE is defined by how quickly the

[47] As a consequence of these costs now being independently estimated, we no longer investigate a standalone sensitivity on these costs as part of the PACR. However, both a 25 per cent increase and decrease in them is reflected in the scenario analysis (as outlined in section 5.1).

Broken Hill load can be restored and the turbines under consideration are able to start-up faster than required under the reliability standard.

We have estimated the absolute level of EUE at Broken Hill under the base case and each credible option. While the RIT-T requires that reliability corrective actions only quantify the changes in EUE over and above that required to meet the applicable reliability standard,[48] the body of this PACR presents EUE in absolute terms since it is more intuitive.[49] We note that estimating EUE in this manner has no bearing on the identification of the preferred option and Appendix D demonstrates this by presenting the analysis in this PACR using only EUE improvements over the IPART reliability standard.

The avoided EUE for each option has been valued using the estimated VCRs published by the AER in December 2021,[50] which have been updated since those used in the PADR. Specifically, we have calculated a load-weighted VCR estimate for the central scenario using the AER VCR values for the four customer groups relevant to Broken Hill. We have then applied VCR estimates that are 30 per cent lower and 30 per cent higher for the low and high scenarios, respectively, consistent with the AER's specified +/- 30 per cent confidence interval.[51]

The EY market modelling has also quantified the impact of changes in involuntary load shedding *outside* of Broken Hill associated with the implementation of each credible option via the time sequential modelling component of the market modelling. Specifically, the modelling estimates the MWh of EUE in each hourly trading interval over the modelling period, and then applies the AER VCRs to quantify the estimated value of avoided EUE outside of Broken Hill for each option.

6.4. Wholesale market benefits

EY has undertaken the wholesale market modelling component of the PACR assessment. As outlined in section 6.2 above, this exercise captures:

- what happens in the NEM and Broken Hill when:
  - Line X2 is in-service; and
  - Line X2 is out-of-service but Broken Hill remains connected to the NEM via a new line (i.e., Option 4).
- what happens in the NEM, outside of Broken Hill, when Line X2 is out-of-service meaning Broken Hill is no longer connected to the NEM.

The credible options are able to affect the wholesale market if they involve:

- energy storage in excess of 250 MWh (the minimum amount required to meet the reliability standards at Broken Hill);
- new turbines; or
- a new transmission line connecting Broken Hill to the NEM.

[48] Clause 9 of the RIT-T states that 'where the credible option is for reliability corrective action, the quantification of the market benefits associated with changes in voluntary load curtailment and changes in involuntary load shedding must only apply in so far as the market benefit delivered by the credible option exceeds the minimum standard required for reliability corrective action' – see: AER, *Final Regulatory Investment Test for Transmission*, June 2010, Clause 9.

[49] We note that this is also consistent with the AER's 'service cost' framework outlined in its industry practice application note for asset replacement planning, as well as the ENA RIT-T Handbook – see: https://www.aer.gov.au/system/files/D19-2978%20-%20AER%20-Industry%20practice%20application%20note%20Asset%20replacement%20planning%20-%2025%20January%202019.pdf & Energy Networks Australia, *RIT-T Economic Assessment Handbook*, 15 March 2019, pp. 42-43.

[50] AER, *Values of Customer Reliability – Final Report on VCR values*, December 2021.

[51] AER, *Values of Customer Reliability – Final Report on VCR values*, December 2019, p. 84.

Acquiring the existing turbines alone does not enable wholesale market benefits as they are currently configured to operate only in islanded mode. The inclusion of fault level upgrades required in order to allow turbines to dispatch into the NEM for arbitrage has been included as a sensitivity test (outlined in section 7.5.3).

As outlined in section 2.2.1, the wholesale market modelling has been updated in this PACR to align with the 2022 ISP step-change, progressive change and hydrogen superpower scenarios.

The specific categories of wholesale market benefit under the RIT-T that have been modelled as part of this PACR are:

- changes in fuel consumption in the NEM arising through different patterns of generation dispatch;
- changes in costs for parties, other than the RIT-T proponent (i.e., changes in investment in generation and storage);
- differences in unrelated transmission investment (in particular, the cost of connecting REZs to the shared network);
- changes in voluntary load curtailment;
- changes in involuntary load curtailment (outside of Broken Hill); and
- changes in network losses.

6.5. General modelling parameters adopted

The RIT-T analysis spans a 27 year assessment period from 2021/22 to 2047/48.[52]

Where the capital components of the credible options have asset lives extending beyond the end of the assessment period, the NPV modelling includes a terminal value to capture the remaining asset life. This ensures that the capital cost of long-lived options over the assessment period is appropriately captured, and that all options have their costs and benefits assessed over a consistent period, irrespective of option type, technology or asset life. The terminal values are calculated as the undepreciated value of capital costs at the end of the analysis period and can be interpreted as a conservative estimate for benefits (net of operating costs) arising after the analysis period.

The RIT-T requires the discount rate used in the NPV analysis to be the commercial discount rate appropriate for the analysis of a private enterprise investment in the electricity sector. A central discount rate of 5.50 per cent (real, pre-tax) has been used in the net present value (NPV) analysis, consistent with the RIT-T requirements and the 2021 AEMO Inputs, Assumptions and Scenarios report (IASR). The cost-benefit assessment has included sensitivity testing with a lower bound discount rate of 1.96 per cent equal to the latest AER Final Decision for a TNSP's regulatory proposal at the time of preparing this PADR,[53] and an upper bound discount rate of 7.50 per cent (consistent with the upper bound in the latest IASR).

[52] The start and end years of the assessment period have been updated since the PADR to reflect the passage of time since the PADR was released and the 25-year market modelling exercise undertaken by EY (from 2023/24 to 2047/48).

[53] This is equal to WACC (pre-tax, real) in the latest final decision for a transmission business in the NEM, see: https://www.aer.gov.au/networks-pipelines/determinations-access-arrangements/ausnet-services-determination-2022%E2%80%9327/final-decision

6.6. Classes of market benefit not considered material

The NER requires that all categories of market benefit identified in relation to the RIT-T are included in the RIT-T assessment, unless the TNSP can demonstrate that a specific category (or categories) is unlikely to be material in relation to the RIT-T assessment for a specific option.[54]

Option value has not been estimated for this RIT-T. There are four pre-requisites required for an option to have option value: (1) there is significant uncertainty about future conditions (eg, demand, spot load etc); (2) there is expected to be 'learning' about that uncertainty in the future (eg, demand continues to increase, or decreases); (3) investment in the options needs to exhibit flexibility to accommodate for the changed circumstances; and (4) there needs to be a possibility of regret (i.e., there is no 'obvious' best alternative under all future outcomes).

While there is the potential for spot load development in the Broken Hill region, there is currently uncertainty in relation to this development, which is expected to lessen over time (i.e., if the potential loads seek formal connection). However, with the exception of Option 1A(4) and the network augmentation considered (Option 4), all of the options in this RIT-T would be able to be scaled to meet future spot loads, and there would be no need for any option to incur additional costs at this stage in order to enable future stages of that option to be implemented. While Option 1A(4) and Option 4 do not exhibit the required flexibility for option value, they are able to avoid significant future costs associated with scaling up to meet additional mining spot loads compared to the smaller options (which would require additional components to meet demand if these loads materialise).

As a consequence, due to the lack of flexibility in Option 1A(4) and Option 4 (and the fact that they can efficiently meet future load without additional components), we have not estimated option value for any of the options.

Competition benefits have also not been estimated for any of the options since they are not considered material in the context of this RIT-T. This RIT-T is focussed on efficiently meeting the required reliability standard at Broken Hill and, while some options are expected to generate a level of wholesale market benefits, it is not considered sufficient to affect the competitiveness of generator bidding behaviour in any region of the NEM.

[54] NER clause 5.16.1(c)(6).

7. Net present value results

This section outlines the results of the assessment we have undertaken of the credible options for this RIT-T.

Due to the confidentiality requested by proponents of solutions, we are only able to present the overall *net* market benefits of each credible option (i.e., the present value of the aggregate market benefits estimated less the present value of the aggregate costs).

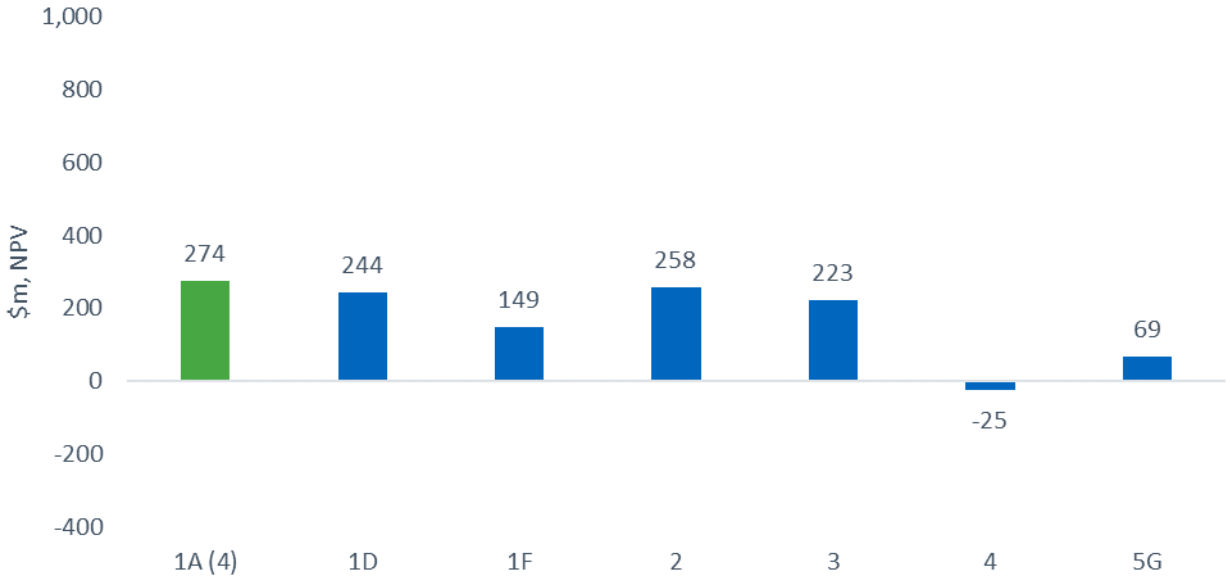
7.1. Central scenario

The central scenario reflects our central view of key underlying assumptions and is considered the most likely scenario in terms of the net market benefits for each of the options. These assumptions include central cost estimates, VCR and commercial discount rate estimates, as well as Broken Hill demand based on the central POE50 demand forecasts. This scenario also includes EY's market modelling of the wholesale market benefits under the 2022 ISP step-change scenario.

Under these assumptions, Option 1A(4) is found to be the top-ranked option and to deliver approximately $274 million in net benefits. Option 1A(4) is projected to deliver net benefits that are approximately 6.3 per cent greater than the second ranked option, Option 2.

Figure 7.1 shows the overall estimated net benefit for each option under the central scenario.

Figure 7.1: Summary of the estimated net benefits under the central scenario



All options provide around $310 million in benefits, in present value terms, from avoided unserved energy at Broken Hill, with the exception of Option 4 which provides an additional $2 million in avoided unserved energy due to the second line providing a marginally higher level of reliability. These values are calculated using POE50 demand forecasts for Broken Hill and a central load-weighted VCR estimate.

If the external funding Hydrostor expects to secure is removed from the analysis, then Option 2 becomes the preferred option, delivering net benefits of $258 million. Without external funding, Option 1A(4) would be expected to deliver $234 million in net benefits, or approximately 91 per cent of the benefits of Option 2.

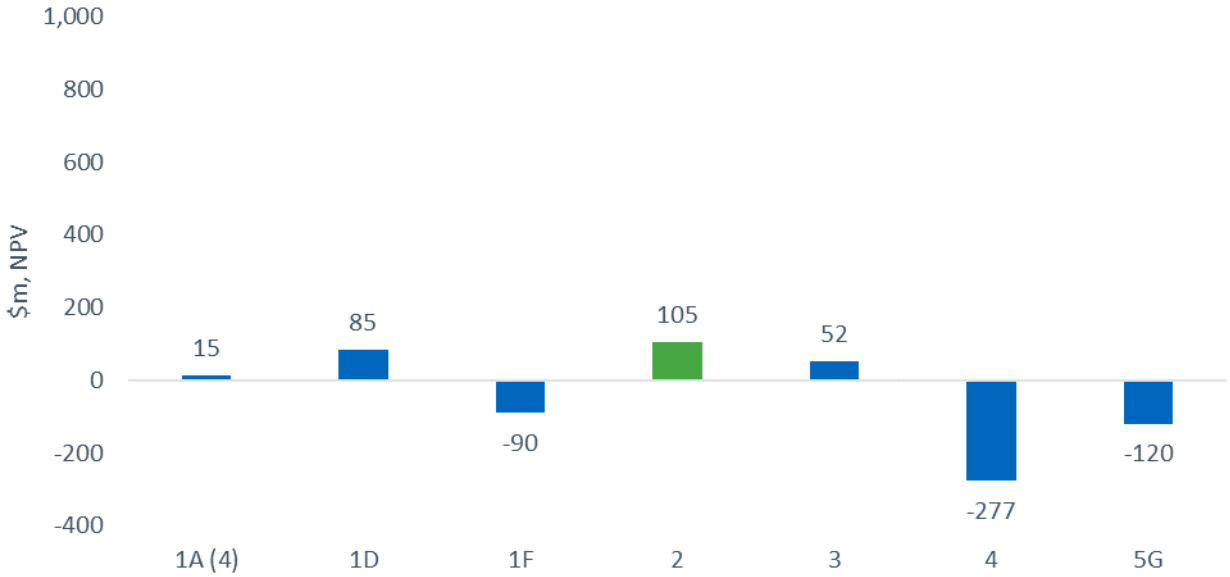
7.2. Low net economic benefits

The low net economic benefits scenario reflects a number of assumptions that gives a lower bound and conservative estimate of net present value of net economic benefits. These assumptions include high cost estimates, low VCR and a high commercial discount rate estimate, as well as Broken Hill demand based on POE90 demand forecasts. This scenario also includes EY's market modelling of the wholesale market benefits under the 2022 ISP progressive change scenario.

Under these assumptions, Option 2 is found to be the top-ranked option and deliver approximately $105 million in net benefits. The second-ranked option, Option 1D, has approximately 19 per cent lower net benefits than Option 2. Option 1A(4) is projected to deliver net benefits of $15 million.

Figure 7.2 shows the overall estimated net benefit for each option under the low benefits scenario.

Figure 7.2: Summary of the estimated net benefits under the low benefits scenario



All options provide around $157 million in benefits from avoided unserved energy at Broken Hill under this scenario, with the exception of Option 4 which provides an additional $1 million in avoided unserved energy due to the second line providing a marginally higher level of reliability. These values are calculated using POE90 demand forecasts for Broken Hill and a low load-weighted VCR estimate.

If the external funding Hydrostor expects to secure removed from the analysis, Option 2 remains the highest ranked option. The only change from Figure 7.2 is that Option 1A(4) would be expected to deliver net costs of $34 million under the low benefits scenario.

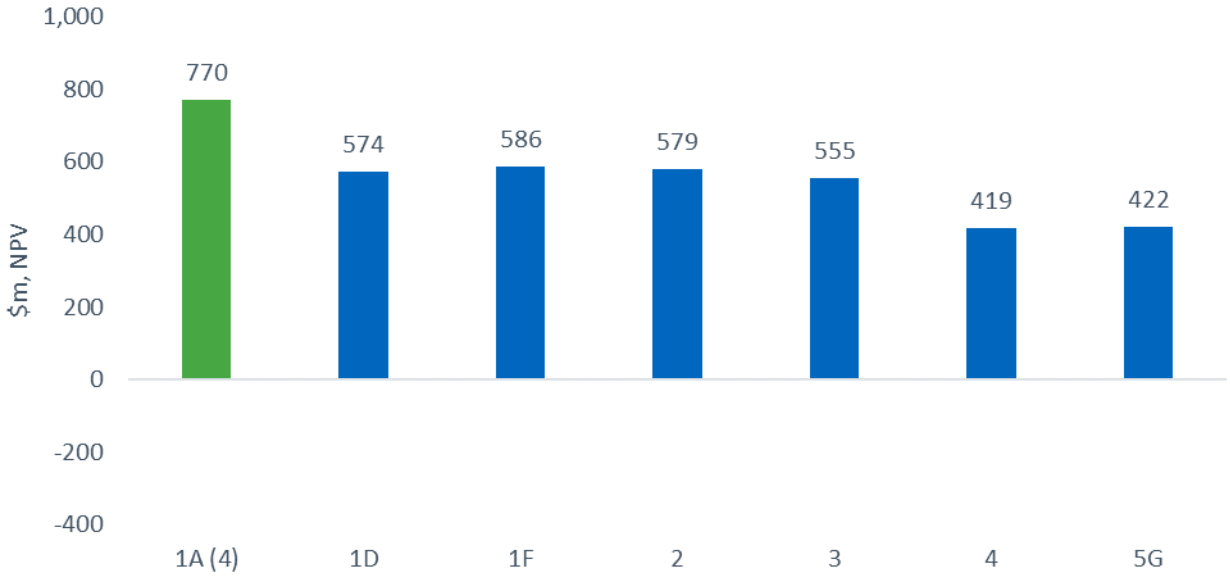
7.3. High net economic benefits

The high net economic benefits scenario reflects a number of assumptions that give an upper bound estimate of net present value of net economic benefits. These assumptions include low cost estimates, high VCR and a low commercial discount rate estimate, as well as Broken Hill demand based on POE10 demand forecasts. This scenario also includes EY's market modelling of the wholesale market benefits under the 2022 ISP hydrogen superpower scenario.

Under these assumptions, the Option 1A(4) is found to be clearly preferred, delivering net benefits of approximately $770 million. Option 1A(4) is projected to deliver net benefits that are 31 per cent greater than the second ranked option, Option 1F, and 33 per cent greater than Option 2.

Figure 7.3 shows the overall estimated net benefit for each option under the high benefits scenario.

Figure 7.3: Summary of the estimated net benefits under the high benefits scenario



All options provide around $639 million in benefits from avoided unserved energy at Broken Hill under this scenario, with the exception of Option 4 which provides an additional $5 million in avoided unserved energy due to the second line providing a marginally higher level of reliability. These values are calculated using POE10 demand forecasts for Broken Hill and a high load-weighted VCR estimate.

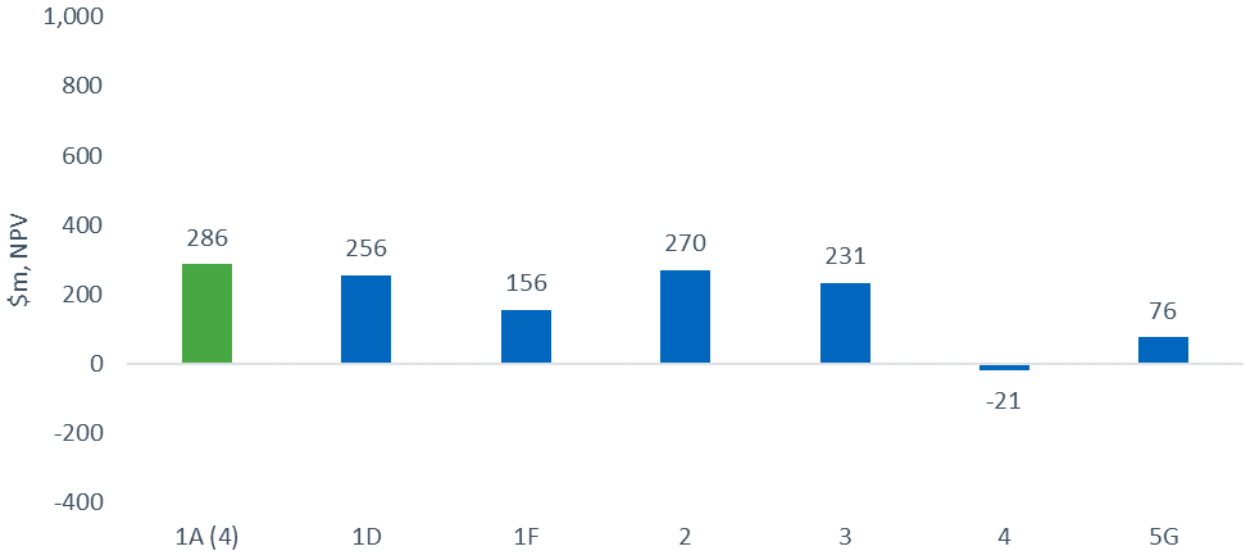
If the external funding Hydrostor expects to secure is removed from the analysis, the Option 1A(4) would still be clearly preferred in the high scenario. Option 1A(4) would be expected to deliver net benefits of $738 million – 26 per cent greater than Option 1F and 28 per cent greater than Option 2.

7.4. Weighted net benefits

Figure 7.4 shows the estimated net benefits for each of the credible options weighted across the three scenarios investigated (and discussed above) using weightings drawn from the draft 2022 ISP.

Under the weighted outcome, Option 1A(4) is found to be the top-ranked option, closely followed by Option 2. Option 1A(4) is projected to deliver approximately $286 million in net benefits, which is approximately 5.8 per cent greater than the second ranked option, Option 2.

Figure 7.4: Summary of the estimated net benefits, weighted across the three scenarios



If the external funding Hydrostor expects to secure is removed from the analysis, then Option 2 becomes the preferred option, delivering net benefits of $270 million. Without external funding, Option 1A(4) would be expected to deliver $244 million in net benefits, or approximately 90 per cent of the benefits of Option 2.

7.5. Sensitivity analysis

In addition to the scenario analysis, we have also considered the robustness of the outcome of the cost benefit analysis through undertaking a range of sensitivity testing. These tests all relate to the central scenario, unless otherwise stated.

The range of factors tested as part of the sensitivity analysis in this PACR are:

- an increase in the capacity of the 330 kV transmission system west of Wagga Wagga, consistent with the outcome of the concurrent 'improving stability in south-western NSW' RIT-T;
- the existing turbines in Option 2 being retro-fitted to be able to dispatch to the NEM and generate wholesale market benefits;
- assuming new mining spot load development in the Broken Hill area;
- alternate commercial discount rate assumptions;
- applying the scenario weightings used in the PADR in place of the draft 2022 ISP scenario weightings;
- the assumed profile of ARENA funding; and
- a decision by Hydrostor to revert to a smaller-sized solution (i.e., Option 1A(2) from the PADR), with no ARENA funding.

Each of the sensitivity tests undertaken in this PACR are discussed in the sections below.

We have not presented a standalone sensitivity below on changes in the underlying network capital costs of the credible options since the low (high) net economic benefits scenario already reflects 25 per cent higher (lower) capital costs for the network elements and we do not expect network costs to vary by more than this amount. Moreover, we note that the preferred option (i.e., Option 1A(4)) involves lower network

capital costs compared to Option 2 and so an increase in network capital costs will make Option 1A(4) more preferred over Option 2.

If there is a 'material change in circumstances', with Option 2 ultimately considered the preferred option and its future cost estimates do increase materially, we would reassess the NPV analysis in light of this change as part of submitting an exemption application from needing to re-apply the RIT-T to the AER (as set out in section 8).

We have also not presented a standalone sensitivity below on changes in the underlying non-network capital costs of the credible options since the low (high) net economic benefits scenario already reflects 25 per cent higher (lower) capital costs for the non-network elements. As part of the future stakeholder update regarding whether there has been a 'material change in circumstances' (as outlined in section 8), we will update the NPV assessment to reflect any changes in the underlying expected non-network costs available at the time.

7.5.1. The capacity of the 330 kV transmission system west of Wagga Wagga

The core market modelling assumes a capacity for the 330 kV transmission system west of Wagga Wagga equivalent to two transmission lines.

We have investigated a sensitivity of the capacity for the 330 kV transmission system west of Wagga Wagga equivalent to three transmission lines under the central scenario (i.e., the existing Darlington Point to Wagga Wagga transmission line and two new Dinawan to Wagga Wagga transmission lines proposed as part of EnergyConnect). This assesses an alternate future with more available capacity west of Wagga Wagga as a result of anticipated investment under a separate RIT-T Transgrid is currently finalising to alleviate a voltage stability limit at Darlington Point.

This sensitivity finds that assuming this increased capacity has no effect on the market benefits of Option 2 and only a minor effect on the overall estimated wholesale market benefits Option 1A(4) (increasing its estimated net benefits by $3.1 million). This coincident network development is therefore not considered to affect the overall ranking of the options under this RIT-T.

7.5.2. Retrofitting the turbines in Option 2 to enable dispatch to the NEM

The PADR investigated a sensitivity where the existing turbines in Option 2 are retrofitted to enable dispatch to the NEM in order to generate wholesale market benefits. Additional costs would need to be incurred in relation to fault level upgrades in order to enable the existing turbines to dispatch into the market and the PADR found that the additional costs incurred are not outweighed by the additional benefits expected.

The updated wholesale market modelling in this PACR continues to find that the cost of retrofitting the turbines ($7.2 million, in present value terms) is not outweighed by the additional market benefits expected ($5.3 million, in present value terms, on a weighted basis).

7.5.3. Future spot load

A number of submissions to the PADR noted the potential for additional mining spot load in the Broken Hill area. As noted earlier, we have engaged further with the prospective mines in the Broken Hill area since the PADR and do not consider that either currently meet the criteria for 'committed' or 'anticipated' status under the RIT-T. However, we have considered whether they are likely to change the conclusion of the PACR if they do go ahead by way of a sensitivity.

The PADR tested two sensitivities involving potential future additional mining development in Broken Hill. Specifically, the PADR considered what additional investments would be required to meet these spot loads under the top-ranked options at the time (the Hydrostor options in the PADR, Option 1D and Option 2). The additional investments considered in each case were additional new technologies (batteries or compressed air storage) or additional new turbines, with both being considered in the case of Option 2.

The PADR sensitivity found that as more mining load connects, the larger Hydrostor options assessed at the time become preferred since they do not require these additional components, or less of them, than Option 2.

The PACR assessment continues to support this conclusion. In particular, Option 1A(4) would be able to accommodate anticipated increases in mining load (upwards of 370 MW) without the need for additional option components. This implies that Option 1A(4) would become relatively more preferred if additional spot load were to eventuate, as its costs would remain the same whilst the cost of Option 2 would increase.

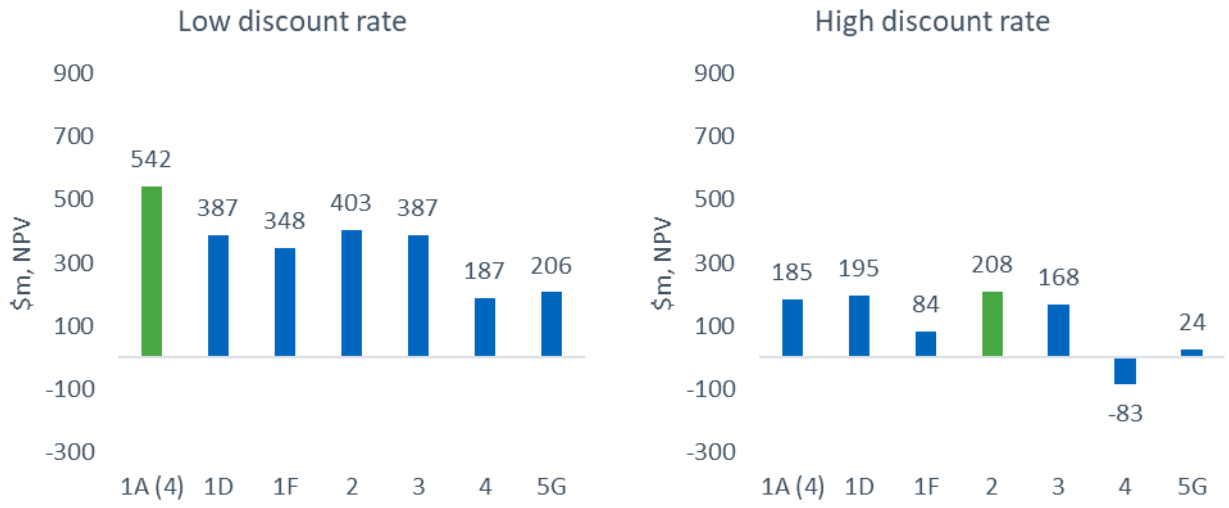
7.5.4. Commercial discount rate assumptions

Figure 7.5 illustrates the sensitivity of the results in the central scenario to different discount rate assumptions in the NPV assessment. In particular, it illustrates two tranches of net benefits estimated for each credible option – namely:

- a high discount rate of 7.50 per cent; and
- a low discount rate of 1.96 per cent.

Figure 7.5 shows that with a low discount rate, Option 1A(4) is clearly preferred, delivering benefits 35 per cent greater than Option 2. With a high discount rate, Option 2 becomes the highest ranked option, delivering benefits 7 per cent greater than Option 1D and 12 per cent greater than Option 1A(4).

Figure 7.5: Impact of different assumed discount rates, central scenario



We do not find a realistic discount rate that would result in Option 1A(4) having a negative net benefit.

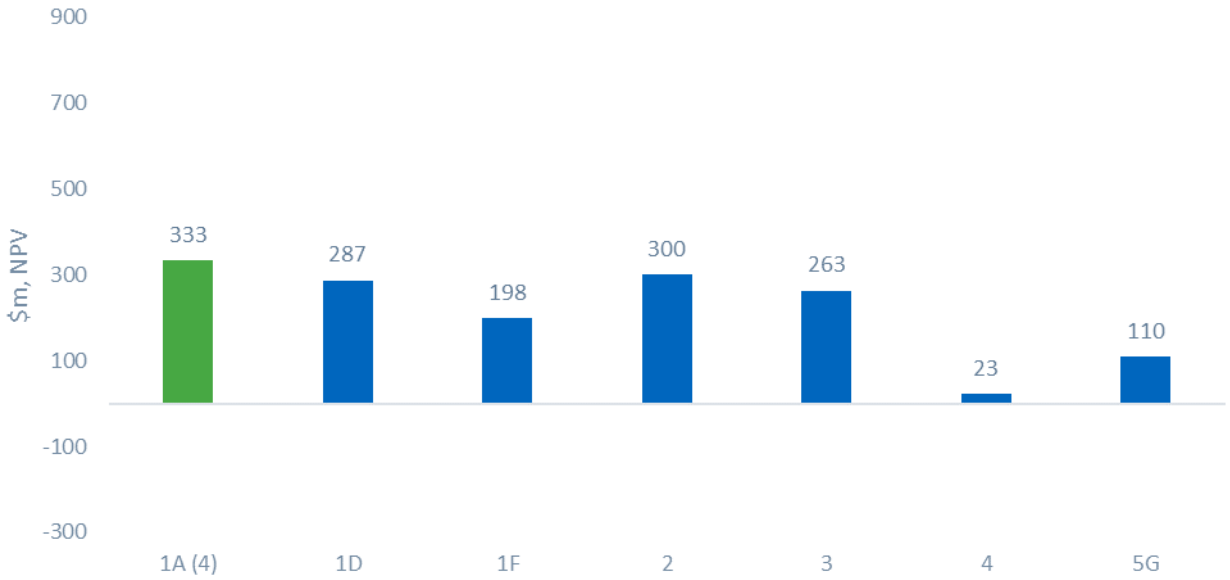
7.5.5. Applying the scenario weightings used in the PADR

While the core assessment in this PACR weights each of the scenarios based on the draft 2022 ISP weightings for the underlying ISP scenarios modelled as part of the wholesale market modelling, we note

that the wholesale market benefits are only one component that affects the ranking of the options in the PACR assessment, i.e., along with discount rates, assumed Broken Hill demand, VCR, capital costs etc (all of which do not vary across the ISP scenarios). We have therefore investigated a sensitivity that applies the scenario weights applied in the PADR assessment, which weights the 'low benefits' and 'high benefits' scenarios equally at 25 per cent each (as opposed to 30 per cent and 18 per cent, respectively) and the central scenario at 50 per cent (since it is comprised of the 'most likely' set of assumptions).

If the scenario weightings from the PADR are applied, the net benefits of all options increase by between $30 and $50 million. Option 1A(4) would be projected to deliver net benefits of $333 million under this alternate weighting, or approximately 11 per cent greater than Option 2.

Figure 7.6: Weighted NPV results using scenario weightings from the PADR



7.5.6. The profile of external ARENA funding

The core results presented in this PACR assume external ARENA funding for Option 1A(4) is provided in a lump sum during the first year of construction. However, actual funding arrangements will depend on commercial negotiations between ARENA and Hydrostor, which are yet to be finalised at the time of this PACR.

We have therefore investigated an alternative profile where the assumed $45 million in ARENA funding is evenly provided over a period of three years (i.e., $15 million each year) coinciding with the construction of the compressed air facility for Option 1A(4).

This alternative profile reduces the net benefits for Option 1A(4) by approximately $2 million but does not change option rankings on a weighted basis, or for individual scenarios. It follows that adopting this different assumed profile for the ARENA funding does not impact the identification of the preferred option under the RIT-T.

7.5.7. Inclusion of Option 1A(2) from the PADR

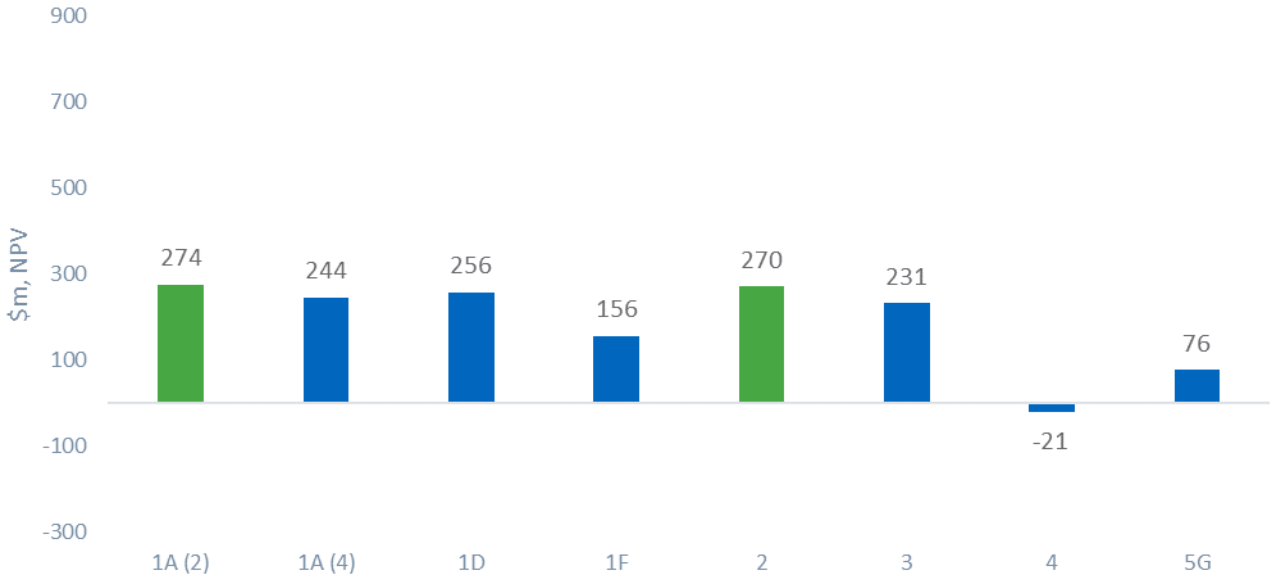
Option 1A(2) from the PADR involved a smaller sized Hydrostor option, which was found at the time to be the top-ranked Hydrostor option. Option 1A(2) would not attract the ARENA funding Hydrostor has secured

for Option 1A(4) (subsequent to the PADR) and Hydrostor has consequently withdrawn this option from the PACR.

However, we have included this sensitivity to investigate how this option would rank compared to the rest of the options in the RIT-T, should Hydrostor decide at a later date to provide the required network support at Broken Hill through a smaller capacity storage option. This sensitivity assumes that there would be no external funding.

We find that Option 1A(2) would be expected to deliver net benefits of approximately $274 million and be effectively ranked equally with Option 2 under this sensitivity (since their estimated net benefits are within 5 per cent).

Figure 7.7: Weighted NPV results including Option 1A(2)



This implies that if Hydrostor and ARENA were not able to conclude an agreement to progress Option 1A(4), and Hydrostor reverted to providing the network support via the smaller sized Option 1A(2), this option would become the preferred option under the RIT-T (albeit preferred equally with Option 2).

8. Conclusion

The assessment in this PACR finds that the continued operation of the existing diesel-fired turbines as an interim measure, followed by network support provided by the Hydrostor compressed air storage solution (Option 1A(4)) is the top-ranked option, followed closely by refurbishing and continuing the long-term use of the existing diesel-fired turbines (Option 2). Option 1A(4) is projected to deliver approximately $286 million in net benefits, which is approximately 5.8 per cent greater than Option 2.[55]

Option 1A(4) involves Transgrid acquiring the existing diesel turbines at Broken Hill from Essential Energy and temporarily using them to provide network support at Broken Hill ahead of Hydrostor installing a 200MW/1500MWh compressed-air energy storage solution that will create a mini-grid at Broken Hill (at which point the turbines will be de-commissioned), and entering into a network support agreement with Transgrid. It involves 50MW and 250MWh dedicated in reserve at all times for reliability support services at Broken Hill and, when not called upon to provide the required reliability, the compressed-air energy storage components would participate in, and add liquidity to, the NEM wholesale market.

Option 2 involves the acquisition by Transgrid of the existing turbines at Broken Hill from Essential Energy, and the refurbishment of the turbines as needed in order to provide long-term reliability of supply to Broken Hill. While Option 2 provides the requisite reliability support services at Broken Hill, it does not allow for any wider wholesale market benefits.

This finding marks a change from the conclusion in the PADR, which found Option 2 to be the top-ranked option (by a 9 to 12 per cent margin over Option 1A(2)), and reflects both an increase in the estimated wholesale market benefit from the energy storage solution (following alignment with the assumptions in the draft 2022 ISP released in December 2022) and that Hydrostor now expects to secure a significant external funding contribution from ARENA for Option 1A(4).

In addition to having a marginally greater expected net benefit, we consider Option 1A(4) to be preferred over Option 2 at this stage since it:

- uses a clean technology that is consistent with the general transition of the electricity sector to low emission technologies – Option 2 has an enduring reliance on fossil fuel technologies as part of the long term solution to meet reliability standards at Broken Hill, which we consider less preferable in the context of the general transition of the electricity sector to low emission technologies, and the Sustainability Strategy of Broken Hill City Council;[56]
- supports the use of innovative solutions to meeting network needs, which may provide an example that can be adopted more widely – we have undertaken a holistic review and are confident that the compressed-air energy storage solution is technically feasible (this review has been supported by an independent technical assurance report from Aurecon);
- is able to efficiently accommodate additional mining load at Broken Hill, should it eventuate – Option 2 would require coupling with additional components to meet this additional load, which would increase the future costs of this option and, potentially, compromise the level of reliability provided to customers in Broken Hill;
- has a lower level of unavailability due to outages (which reduces the risk of disruptions to customer supply in Broken Hill) – Option 2 requires significant refurbishment of the existing turbines that requires them to be out of service while this is undertaken; and

[55] If the ARENA funding is removed from the assessment, Option 2 becomes the preferred option (unless Hydrostor were to decide to pursue Option 1A(2) – see section 7.5.7).

[56] Broken Hill City Council, *Sustainability Strategy 2018-2023*.

- is expected to have a further modest increase in net benefits if more available transmission capacity west of Wagga Wagga is assumed as a result of the anticipated investment under the separate RIT-T Transgrid is currently finalising to alleviate a voltage stability limit at Darlington Point – this development would not affect the net benefits of Option 2.

Notwithstanding the above, we consider that if either of the following two events occur, they would likely constitute a 'material change in circumstances' (i.e., under clause 5.16.4(z3) of the NER):

1. ARENA and Hydrostor not being able to finalise a funding agreement with a sufficient upfront external capital contribution; or

2. Transgrid and Hydrostor not being able to finalise a network support contract that is expected to be accepted as prudent and efficient by the AER.

However, should either of these events occur, we would seek an exemption from the AER under clause 5.16.4(z3) of the NER to avoid having to reapply the RIT-T. Specifically, we consider that, should either of the above events occur, then the analysis presented in this PACR demonstrates that Option 2 should be considered the preferred option under this RIT-T, unless Hydrostor were to decide to pursue the smaller sized Option 1A(2), in which case this would become the preferred option.

We consider this approach provides sufficient confidence that Transgrid will be able to progress an option to ensure the required reliability to consumers at Broken Hill at an efficient cost level without having to re-do the RIT-T. We note that re-doing the RIT-T would take significant time, which would compromise the reliability of supply to customers at Broken Hill and ultimately likely cost all NSW electricity customers more in the long-run.

We note that the Rules regarding a 'material change in circumstances', and the ability to include a 'decision rule' in a PACR, is currently being considered by Australian Energy Market Commission.[57] In the event that the NER changes following this PACR, we would consider the two events above to constitute two elements of a decision rule for ultimately determining the preferred option for this RIT-T.

We will be liaising closely with ARENA and Hydrostor to monitor how Option 1A(4) progresses through the various 'stage gates' ARENA has identified for its funding, in order to assess whether the above conditions are expected to be met within the timeframes outlined in this PACR.

We note that the assumptions around external funding reflected in this PACR area consistent with information provided by ARENA to Transgrid, but that the agreement remains subject to negotiation between ARENA and Hydrostor.

In terms of the upfront capital contribution, we consider a 'sufficient' amount to be an amount that results in Option 1A(4) being either within 5 per cent of, or outright preferred to, Option 2 on a weighted basis across the three scenarios assessed. While we note that this value depends on a range of factors, including the assumed cost of Option 1A(4), we currently consider this value to be at least $13.2 million based on the PACR assessment.[58] We intend to confirm that the eventual agreed external funding amount is considered sufficient as part of the future update to stakeholders relating to the conditions above.

[57] AEMC, *Transmission Planning and Investment Review*, Consultation Paper, 19 August 2021, p. 54.

[58] We consider net benefit outcomes within 5 per cent of each other to be effectively equal. In the context of the external funding, we find that it would need to be at least $13.2 million in order for Option 1A(4) to be within 5 per cent of Option 2 (whereas, in order for Option 1A(4) to have exactly the same net benefit as Option 2, $27.9 million in external funding would be required).

Assuming Option 1A(4) remains preferred, the start-date for the network support contract would coincide with the expected commissioning date for the compressed-air solution in 2025/26.

We will update stakeholders when we consider either that both the external funding agreement and the network support agreement for Option 1A(4) are sufficiently certain, or at the point we determine there has been a material change in circumstances and that either Option 2 or Option 1A(2) should instead be progressed (i.e., when we would submit an exemption to the AER from having to reapply the RIT-T).

Appendix A Compliance checklist

This section sets out a compliance checklist which demonstrates the compliance of this PACR with the requirements of clause 5.16.4(v) of the National Electricity Rules version 180.

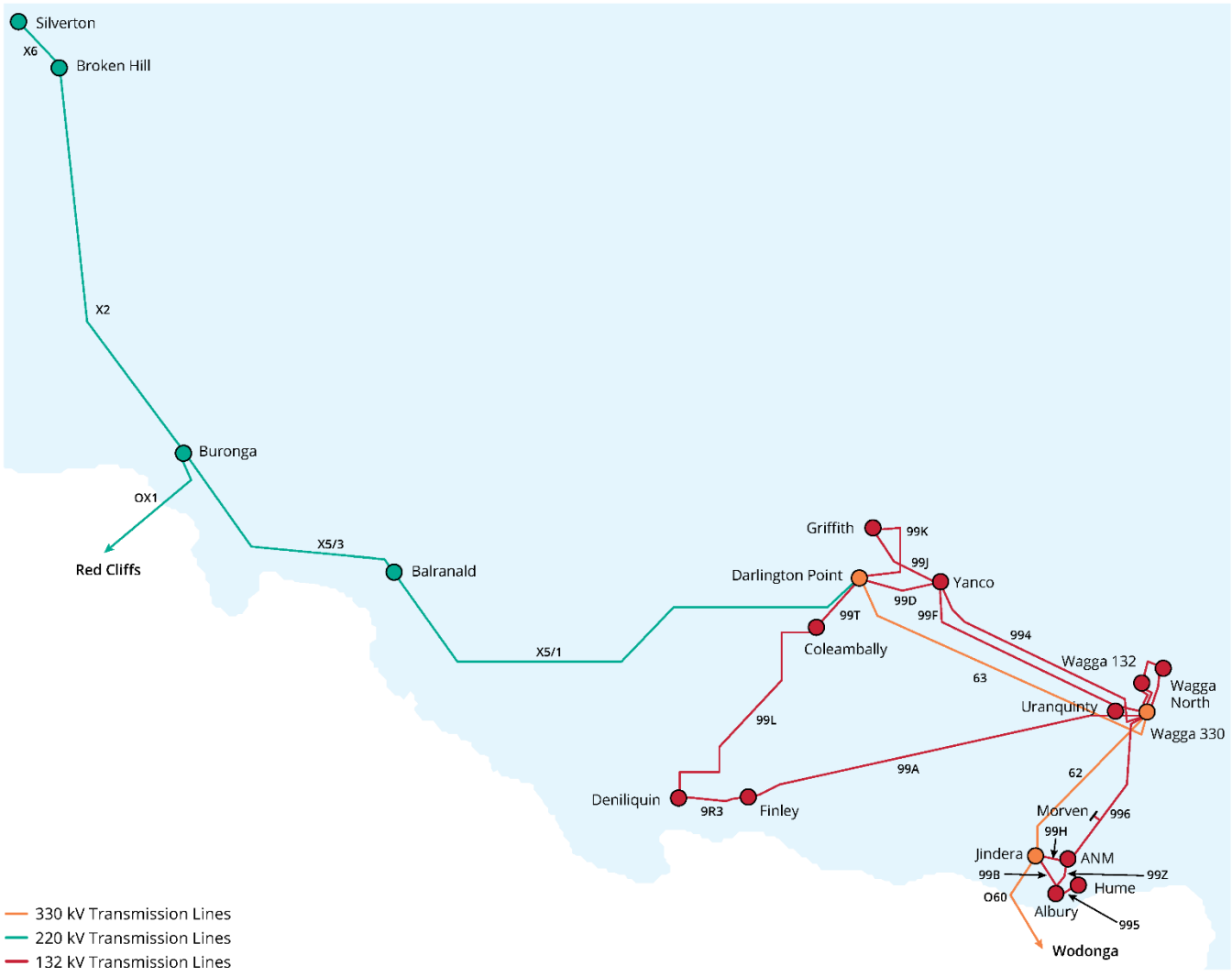
Rules clause	Summary of requirements	Relevant section(s) in the **PACR**
5.16.4(v)	The project assessment conclusions report must set out:	-
	(1) the matters detailed in the project assessment draft report as required under paragraph (k)	See below.
	(2) a summary of, and the RIT-T proponent's response to, submissions received, if any, from interested parties sought	3 Appendix E
5.16.4(k)	The project assessment draft report must include:	-
	(1) a description of each credible option assessed;	4
	(2) a summary of, and commentary on, the submissions to the project specification consultation report;	3
	(3) a quantification of the costs, including a breakdown of operating and capital expenditure, and classes of material market benefit for each credible option;	4 & 7
	(4) a detailed description of the methodologies used in quantifying each class of material market benefit and cost;	6
	(5) reasons why the RIT-T proponent has determined that a class or classes of market benefit are not material;	6
	(6) the identification of any class of market benefit estimated to arise outside the region of the Transmission Network Service Provider affected by the RIT-T project, and quantification of the value of such market benefits (in aggregate across all regions);	7
	(7) the results of a net present value analysis of each credible option and accompanying explanatory statements regarding the results;	7
	(8) the identification of the proposed preferred option;	8
	(9) for the proposed preferred option identified under subparagraph (8), the RIT-T proponent must provide: (i) details of the technical characteristics; (ii) the estimated construction timetable and commissioning date; (iii) if the proposed preferred option is likely to have a material inter-network impact and if the Transmission Network Service Provider affected by the RIT-T project has received an augmentation technical report, that report; and (iv) a statement and the accompanying detailed analysis that the preferred option satisfies the regulatory investment test for transmission.	8

Appendix B Overview of existing electricity supply arrangements at Broken Hill

Broken Hill is part of the south-western transmission network and is supplied by a single 220 kV transmission line, Line X2, from Buronga that is around 260 km long.

The current electricity network supplying Broken Hill is shown in Figure B-8.1 below.

Figure B-8.1: South western NSW transmission network



The average electricity demand at Broken Hill substation is approximately 40 MW.[59]

In addition, Broken Hill Solar Plant (53 MW) and Silverton Wind Farm (200 MW) are both connected to Broken Hill substation.

[59] Transgrid, *Transmission Annual Planning Report 2018*, available at: https://www.Transgrid.com.au/news-views/publications/Documents/Transmission%20Annual%20Planning%20Report%202018%20Transgrid.pdf

During a planned or unplanned outage of Line X2, Broken Hill has been supplied by Essential Energy's two back-up turbines that run on diesel fuel.[60]

These turbines:

- each have nominal capacity rating of 25 MW, which is reduced to 18 MW under adverse ambient temperature conditions; and
- are black-start capable and equipped for islanded operation.

We have relied on these turbines to meet our obligations under NSW Electricity Transmission reliability standards as determined by IPART.

The reliability standards applicable to Broken Hill are set out in Table B-4 below and currently require us to reliably supply the load at Broken Hill and maintain less than 10 minutes of EUE at average demand.[61]

Table B-4: IPART reliability standards applicable to Broken Hill from 2018/19 onward

Broken Hill	Redundancy category [62]	Average demand (MW)	Unserved energy allowance (minutes)	Estimated unserved energy allowance (MWh)
Broken Hill 220 kV	1	19 MW	10 minutes (grouped)	3.2 MWh
Broken Hill 22 kV	1	21 MW		3.5 MWh
Total	1	40 MW	10 minutes	7 MWh

[60] Broken Hill Solar Plant and Silverton Wind Farm are not presently configured to be able to generate in an event of an outage of Line X2.

[61] IPART, *NSW Electricity Transmission Reliability and Performance Standard 2017*, available at: https://www.ipart.nsw.gov.au/files/sharedassets/website/shared-files/licensing-compliance-electricity-transmission-reliability/nsw-electricity-transmission-reliability-and-performance-standard-2017.pdf

[62] Redundancy category level 1 means a supply interruption may occur following the outage of a single system element.

Appendix C Overview of the wholesale market modelling undertaken

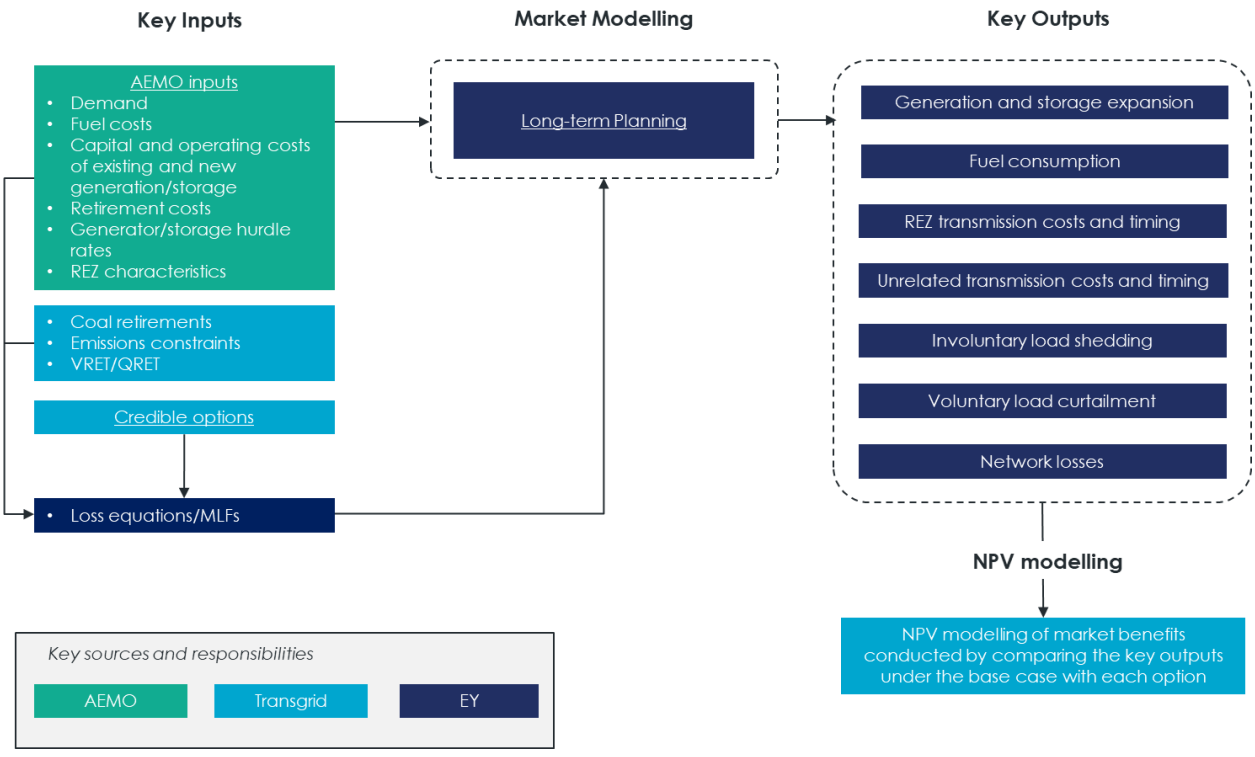
As outlined in the body of this PACR, we engaged EY to undertake the wholesale market modelling as part of this PACR.

EY has applied a linear optimisation model and performed hourly, time-sequential, long-term modelling for the NEM to estimate categories of wholesale market benefits expected under the options that affect the wholesale market. Specifically, EY has undertaken market simulation exercise involving long-term investment planning, which identifies the optimum generation (including storage) and unrelated transmission infrastructure development schedule, while meeting reserve requirements, policy objectives, and technical generator and network performance limitations. This solves for the least-cost generation and transmission infrastructure development across the assessment period while meeting energy policies.

These exercises are consistent with an industry-accepted methodology, including within AEMO's ISP.

Figure C.8.2 illustrates the interactions between the key modelling exercises, as well as the primary party responsible for each exercise and/or where the key assumptions have been sourced.

Figure C.8.2: Overview of the market modelling process and methodologies



The sub-sections below provide additional detail on the key wholesale market modelling exercises EY have undertaken as part of this PACR assessment.

Long-term Investment Planning

The Long-term Investment Planning's function is to develop generation (including storage) and unrelated transmission infrastructure forecasts over the assessment period for each of the credible options and base case.

This exercise determines the least-cost development schedule for each credible option drawing on assumptions regarding demand, emissions reduction and renewable energy targets, reservoir inflows, generator outages, wind and solar generation profiles, and maintenance over the assessment period.

The generation and transmission infrastructure development schedule resulting from the Long-term Investment Planning is determined such that:

- it economically meets hourly regional and system-wide demand while accounting for network losses;
- it builds sufficient generation capacity to meet demand when economic while considering potential generator unplanned and planned outages;
- the cost of unserved energy is balanced with the cost of new generation investment to supply any potential shortfall;
- generator's technical specifications such as minimum stable loading, and maximum capacity are observed;
- notional interconnector flows do not breach technical limits and interconnector losses are accounted for;
- hydro storage levels and battery storage state of charge do not breach maximum and minimum values and cyclic losses are accounted for;
- new generation capacity is connected to locations in the network where it is most economical from a whole of system cost;
- NEM-wide emissions constraints are adhered to;
- NEM-wide and state-wide renewable energy targets are met;
- regional and mainland reserve requirements are met;
- energy-limited generators such as Tasmanian hydro-electric generators, Snowy Hydro-scheme and grid-scale batteries are scheduled to minimise system costs; and
- the overall system cost spanning the whole outlook period is optimised whilst adhering to constraints.

The Long-term Investment Planning adopts the same commercial discount rate as used in the NPV discounting calculation in the cost benefit analysis. This is consistent with the approach being taken in the 2022 ISP (and was applied in the 2020 ISP and the inaugural 2018 ISP).[63]

Coal-fired and gas-fired generation is treated as dispatchable between its minimum load and its maximum load in the modelling. Coal-fired 'must run' generation is dispatched whenever available at least at its minimum load. Open cycle turbines are typically bid at their short run marginal cost with a zero minimum load level, and started and operated whenever the price is above that level.

The Long-term Investment Planning model ensures there is sufficient dispatchable capacity in each region to meet peak demand in the region, plus a reserve level sufficient to allow for generation or transmission contingences which can occur at any time, regardless of the present dispatch conditions.

[63] AEMO, *Planning and Forecasting 2019 Consultation Process Briefing Webinar*, Wednesday 3 April 2019, slide 21.

Due to load diversity and sharing of reserve across the NEM, the reserve to be carried is minimised at times of peak, and provided from the lowest cost providers of reserve including allowing for each region to contribute to its neighbours reserve requirements through interconnectors.

Modelling of diversity in peak demand

The market modelling accounts for peak period diversification across regions by basing the overall shape of hourly demand on nine historical years ranging from 2010/11 to 2018/19.

Specifically, the key steps to accounting for this diversification are as follows:

- the historical underlying demand has been calculated as the sum of historical metered demand and the estimated rooftop PV generation based on historical rooftop PV capacity and solar insolation;
- the nine-year hourly pattern has been projected forward to meet future forecast annual peak demand and energy in each region;
- the nine reference years are repeated sequentially throughout the modelling horizon; and
- the future hourly rooftop PV generation has been estimated based on insolation in the corresponding reference year and the projection of future rooftop PV capacity, which is subtracted from the forecast underlying demand along with other behind-the-meter components (e.g., electric vehicles and domestic storage) to get a projection of hourly operational demand.

This method ensures the timing of peak demand across regions reflects historical patterns, while accounting for projected changes in rooftop PV generation and other behind-the-meter loads and generators that may alter the diversity of timing.

Modelling of intra-regional constraints

The wholesale market simulations include models for intra-regional constraints in addition to the inter-regional transfer limits.

Key intra-regional transmission constraints in New South Wales have been captured by splitting NSW into zones (NNS, NCEN, CAN and SWNSW), and explicitly modelling intra-regional connectors across boundaries or cut-sets between these zones. Bi-directional flow limits and dynamic loss equations were formulated for each intra-regional connector.

Summary of the key assumptions feeding into the wholesale market exercise

The table below summarises the key assumptions that the market modelling exercise draws upon.

Table C-5: PACR modelled scenario's key drivers input parameters

Key drivers input parameters	Step change	Progressive change	Hydrogen superpower
Underlying consumption	ESOO 2021 (draft ISP 2022) – step change	ESOO 2021 (draft ISP 2022) – progressive change	ESOO 2021 (draft ISP 2022) – hydrogen superpower
New entrant capital cost for wind, solar PV, SAT, OCGT, CCGT, PSH, and large-scale batteries	2021 Inputs and Assumptions Workbook – step change	2021 Inputs and Assumptions Workbook – progressive change	2021 Inputs and Assumptions Workbook – hydrogen superpower

Key drivers input parameters	Step change	Progressive change	Hydrogen superpower
Retirements of coal-fired power stations	2021 Inputs and Assumptions Workbook – step change In line with expected closure year, or earlier if economic or driven by decarbonisation objectives	2021 Inputs and Assumptions Workbook – progressive change In line with expected closure year, or earlier if economic or driven by decarbonisation objectives beyond 2030	2021 Inputs and Assumptions Workbook – hydrogen superpower In line with expected closure year, or earlier if economic or driven by decarbonisation objectives
Gas fuel cost	2021 Inputs and Assumptions Workbook – step change Lewis Grey Advisory 2020, step change	2021 Inputs and Assumptions Workbook – progressive change Lewis Grey Advisory 2020, central	2021 Inputs and Assumptions Workbook – hydrogen superpower Lewis Grey Advisory 2020, step change
Coal fuel cost	2021 Inputs and Assumptions Workbook – step change Wood Mackenzie, step change	2021 Inputs and Assumptions Workbook – progressive change Wood Mackenzie, central	2021 Inputs and Assumptions Workbook – hydrogen superpower Wood Mackenzie, step change
NEM carbon budget to achieve 2050 emissions levels	2021 Inputs and Assumptions Workbook – step change 891 Mt CO_2-e 2023-24 to 2050-51	2021 Inputs and Assumptions Workbook – progressive change 932 Mt CO_2-e 2030-31 to 2050-51	2021 Inputs and Assumptions Workbook – hydrogen superpower 453 Mt CO_2-e 2023-24 to 2050-51
Victoria Renewable Energy Target (VRET)	40 % renewable energy by 2025 and 50 % renewable energy by 2030 VRET 2 including 600 MW of renewable capacity by 2025		
Queensland Renewable Energy Target (QRET)	50 % by 2030		
Tasmanian Renewable Energy Target (TRET)	2021 Inputs and Assumptions Workbook: 200 % Renewable generation by 2040		
NSW Electricity Infrastructure Roadmap	2021 Inputs and Assumptions Workbook: 12 GW NSW Roadmap, with 3 GW in the Central West Orana (CWO) REZ, modelled as generation constraint per the draft 2022 ISP 2 GW of long duration storage (8 hrs or more) by 2029-30		
EnergyConnect	Draft 2022 ISP – EnergyConnect commissioned by July 2025		
Western Victoria Transmission Network Project	Draft 2022 ISP – Western Victoria upgrade commissioned by November 2025		
HumeLink	Draft 2022 ISP – step change: HumeLink commissioned by July 2028	Draft 2022 ISP – progressive change: HumeLink commissioned by July 2035	Draft 2022 ISP – hydrogen superpower: HumeLink commissioned by July 2027
Marinus Link	Draft 2022 ISP –1st cable commissioned by July 2029 and 2nd cable by July 2031		
Victoria to NSW Interconnector Upgrade (VNI Minor)	Draft 2022 ISP – VNI Minor commissioned by December 2022		
NSW to QLD Interconnector Upgrade (QNI Minor)	Draft 2022 ISP – QNI minor commissioned by July 2022		
QNI Connect	Draft 2022 ISP – step change: QNI Connect commissioned by July 2032	Draft 2022 ISP – progressive change: QNI Connect commissioned by July 2036	Draft 2022 ISP – hydrogen superpower: QNI Connect commissioned by July 2029 and stage 2 to be commissioned by July 2030
VNI West	Draft 2022 ISP – step change: VNI West commissioned by July 2031	Draft 2022 ISP – progressive change: VNI West commissioned by July 2038	Draft 2022 ISP – hydrogen superpower: VNI West commissioned by July 2030
Victorian SIPS	Draft 2022 ISP – 300 MW/450 MWh, 250 MW for SIPS service and the remaining 50 MW can be deployed in the market by the operator on a commercial basis, November 2021.		

Key drivers input parameters	Step change	Progressive change	Hydrogen superpower
New-England REZ Transmission	Draft 2022 ISP – step change: New England REZ Transmission Link commissioned by July 2027, New England REZ Extension commissioned by July 2035	Draft 2022 ISP – progressive change: New England REZ Transmission Link commissioned by July 2027, New England REZ Extension commissioned by July 2038	Draft 2022 ISP – hydrogen superpower: New England REZ Transmission Link commissioned by July 2027, New England REZ Extension commissioned by July 2031, and stage 3 by July 2042
Snowy 2.0	2021 Inputs and Assumptions Workbook – Snowy 2.0 is commissioned by December 2026		

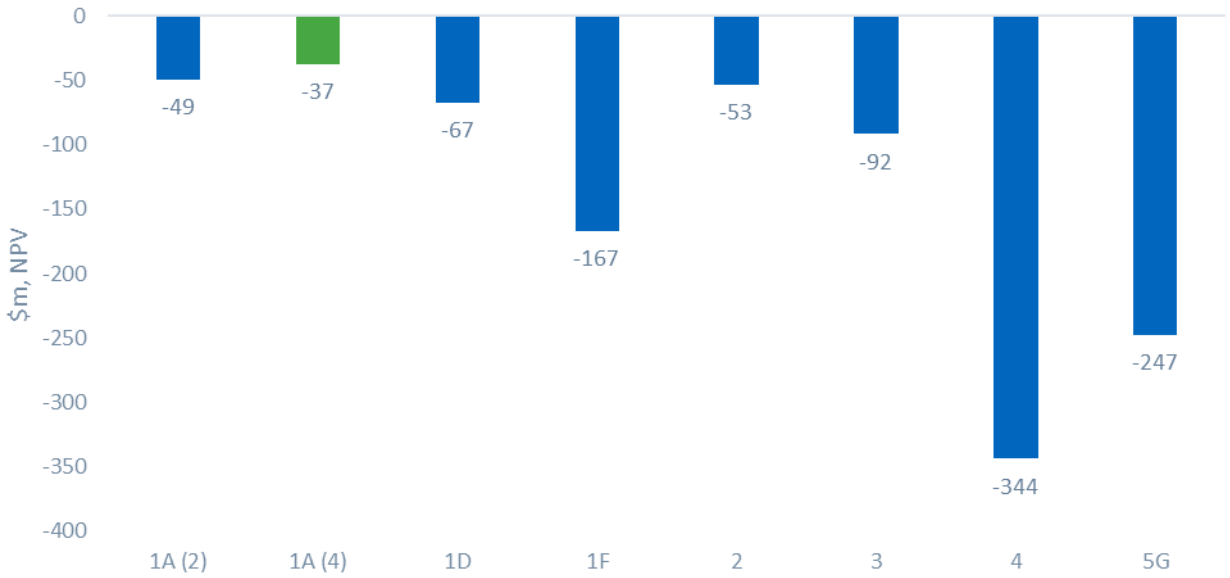
Appendix D Analysis using EUE improvements over the reliability standard

As outlined in section 6.3, we have estimated the absolute level of EUE at Broken Hill under the base case and each credible option for the analysis presented in the body of this report.

While the RIT-T requires that reliability corrective actions only quantify the changes in EUE over and above that required to meet the applicable reliability standard,[64] the body of this PACR presents EUE in absolute terms since it is more intuitive.[65] Estimating EUE in this manner has no bearing on the identification of the preferred option and this appendix demonstrates this by presenting the analysis in this PACR using only EUE improvements over the IPART reliability standard.

The figure below presents the weighted net market benefit results for each of the credible options and finds that, while Option 1A(4), the preferred option from the core assessment, is now found to have marginally negative net benefits, the absolute difference between the options is the same as the core results.

Figure D-8.3: Analysis using EUE improvements over the reliability standard, weighted NPVs



The key difference compared to the analysis in the body of the report is that all options now have negative estimated net market benefits on account of the analysis excluding all avoided EUE except that which exceeds the reliability standard. However, under a reliability corrective action RIT-T, the preferred option is permitted to have negative net market benefits but must still be the top-ranked option, i.e., be the lowest net cost way of meeting the required reliability standard.

[64] Clause 9 of the RIT-T states that 'where the credible option is for reliability corrective action, the quantification of the market benefits associated with changes in voluntary load curtailment and changes in involuntary load shedding must only apply in so far as the market benefit delivered by the credible option exceeds the minimum standard required for reliability corrective action' – see: AER, *Final Regulatory Investment Test for Transmission*, June 2010, Clause 9.

[65] We note that this is also consistent with the AER's 'service cost' framework outlined in its industry practice application note for asset replacement planning, as well as the ENA RIT-T Handbook – see: https://www.aer.gov.au/system/files/D19-2978%20-%20AER%20-Industry%20practice%20application%20note%20Asset%20replacement%20planning%20-%2025%20January%202019.pdf & Energy Networks Australia, *RIT-T Economic Assessment Handbook*, 15 March 2019, pp. 42-43.

Appendix E Summary of consultation on the PADR

This appendix provides a summary of points raised by stakeholders during the PADR consultation process, besides those raised in confidential submissions.

The points raised are grouped by topic and a response is provided to every point raised. All section references are to this PACR, unless otherwise stated.

Summary of comment(s)	Submitter(s)	Our response
Use of a compressed-air energy storage solution		
Hydrostor's A-CAES technology is based on well-proven compressed-air long duration storage technology. The viability of compressed-air storage solutions has been validated by analysis by leading experts such as NREL and the Energy Estate technical team (x-Arup, KBR, John Holland) have undertaken our own extensive due diligence and assessment of the technology and its applicability to the Broken Hill site.	Energy Estate, p. 2	Noted. We have completed a holistic technical review of the compressed-air storage options considered in this PACR, and are confident that the solution is technically feasible. This review has been supported by an independent technical assurance report from Aurecon.
Energy Estate has committed substantial resources to the development of the Broken Hill A-CAES project after becoming comfortable that it is the right technology for the Broken Hill consumers.	Energy Estate, p. 2	
We acknowledge the many benefits this solution may be able to deliver, including: • repurposing of an end of life mine located in Broken Hill; • providing new employment and skills opportunities; • supporting sustained economic growth with new sources of revenue; and • supporting more renewable energy generation in the region with better economic returns.	Broken Hill City Council, p. 3	See section 3.1.
Hydrostor, Energy Estate and Broken Hill City Council emphasised the following figures from an independent report by ACIL Allen[66]: the solution can deliver investment in the order of $500m in the Broken Hill region, creating many direct and indirect jobs and making a total contribution of more than $1bn to the local economy for 40+ years operational lifetime.	Hydrostor, p. 2 Broken Hill City Council, p. 3 Energy Estate, p. 2	

[66] Economic Impacts of the Broken Hill A-CAES, ACIL Allen June 2021

Summary of comment(s)	Submitter(s)	Our response
The synchronous AC generation system of A-CAES can provide all primary ancillary network services and black start, enhancing system strength and improving network operation. The A-CAES solution will have a very significant positive impact on the well-publicised MLF and curtailment issues facing the wind and solar farms currently operating in Broken Hill. The additional of a large-scale energy storage solution of this type at Broken Hill is also forecast to benefit many other generators in the West Murray Zone (and this was confirmed by analysis conducted for us by ACIL Allen). We are excited about the opportunities which will be unlocked to develop new renewable energy generation in Broken Hill due to the firming options which will be delivered by the A-CAES solution and deliver low-cost clean energy to new users such as Cobalt Blue and Hawson's Iron Ore.	Energy Estate, p. 2	See section 3.1.
Inadequacy of the options involving diesel turbines over the long-term		
Current inability of diesel turbines to meet mining load		
The diesel-fired turbines have mostly provided backup power from one of the two units, since using both has not been dependable. Existing mining operations have been forced to provide their own onsite power generation at their own cost during periods of grid outage, instead of being adequately supported with reliable backup power, this has in the past caused major disruption and economic loss to the mines and to the town.	Broken Hill City Council, p. 2	We note that the arrangements with the existing mines at Broken Hill are expected to remain in place and not to change as a consequence of this RIT-T.
In the event of a transmission line outage mine operators in the region are currently instructed by Essential Energy to significantly curtail their demand as the existing diesel plant cannot reliably sustain the total demand on the Broken Hill distribution system. Apart from the significant financial impost this has on mining operations it also poses safety risks to their underground mining operations and has resulted in the need for manual evacuations in the past.	Hydrostor, p.5	
If the transmission line goes down, mines are instructed by Essential Energy to reduce/curtail their demand as the old diesel plant cannot reliably meet total demand.	Energy Estate, p. 3	
Inadequacy of the turbines over the long-term		
There is no detailed or convincing justification of the ability of the diesel-fired turbines to function successfully and reliably in the long-term in the PADR.	Broken Hill City Council, p. 2	See section 3.2.

Summary of comment(s)	Submitter(s)	Our response
The diesel turbines, given the age and operating history, have not been adequately demonstrated to be reliable as a long-term solution.	Hydrostor, p. 5	
Without clear independent verification of actual turbine condition, for example through an independent physical inspection report on the diesel turbines, it can only be assumed that the condition of the diesel turbines is commensurate with their age and that they would not be suited for an application requiring prolonged or regular operation. The PADR does not describe what changes will be made to the existing diesel turbines to mitigate their deteriorated condition to provide for increased operation in the future.	Hydrostor, p. 5	
We understand that the Aurecon report referred to in the revised PADR was conducted on a desktop basis and they were unable to inspect the turbines. We find it surprising that on the basis of a desktop analysis of 40-year-old turbines anyone is able to make an assertion that they will be able to continue operating for decades. In addition, the PADR has assumed that no material expenditure will be required or prudent in order to achieve this stated goal. Our team has decades of experience in relation to the operation of such diesel gensets in multiple markets here and globally. As the owners of such gensets we would not be comfortable making such assumptions and would include appropriate costs and contingencies if we were being required to ensure that such gensets remain available for years to come.	Energy Estate, p. 3	
Consistency of diesel generator solution with other policy/vision		
Hydrostor and Broken Hill City Council both point out that the prolonged use of diesel generators is inconsistent with: • NSW Government's Electricity Infrastructure Roadmap, which seeks to transform its electricity system into one that is "cheap, clean and reliable" and includes a target of 2GW long duration storage. • NSW Government target of 50% reduction by 2030 and net zero by 2050 • Commonwealth Government's net zero policy by 2050 and a 35% reduction in emissions by 2030. • AER's commitment to the newly launched international Regulatory Energy Transition Accelerator.	Broken Hill City Council, p. 1 Hydrostor, p. 3	See section 3.2.
We believe they do not reflect the reality of the current environment and the direction of energy markets in NSW and across Australia. It is inconsistent with NSW Government's Electricity Infrastructure Roadmap, NSW's Net Zero Plan...AER's commitment to the newly launched international Regulatory Energy Transition Accelerator…	Energy Estate, p. 2	

Summary of comment(s)	Submitter(s)	Our response
We struggle to understand how this proposed life-extension of the diesel-fired turbines supports Transgrid's own corporate vision of "A clean energy future for Australia", particularly given previous consultation with Council where reliability solutions that could support a renewable energy mini-grid were presented.	Broken Hill City Council, p. 2	
The prolonged use of diesel generators is also inconsistent with… Transgrid's corporate vision of "A clean energy future for Australia" and a backward step in Transgrid's 5-star rating by the Global Real Estate Sustainability Benchmark (GRESB) 2020 ESG benchmarking report (and presumably Transgrid's upcoming corporate ESG Strategy to be released before the end of 2021).	Hydrostor, p. 3	
It is inconsistent with … Transgrid's recently released vision…	Energy Estate, p. 2	
The retention of diesel-fired turbines is also at odds with Council's Renewable Energy Action Plan (REAP) which calls for Council to decrease its reliance on non-renewable energy, attract renewable energy business and innovation to the city, and play its part in mitigating climate change.	Broken Hill City Council, p. 2	
Hydrostor and Energy Estate both point to concerns noted by Transgrid in its revised PADR that "prolonging the use of fossil fuel technologies is inconsistent with Broken Hill's City Council's Sustainability Strategy and the general transition of the electricity sector to low emission technologies." [page 7 PADR]	Hydrostor, p. 3 Energy Estate, p. 2	
The AER requires Network Service Providers to take into account feedback from the community and stakeholders. The feedback from the Broken Hill community and stakeholders is clear that Transgrid should not progress with the acquisition of the diesel generators and select the highest-ranking clean energy option in the PADR.	Hydrostor, p. 3	
Condition of the transmission line between Buronga and Broken Hill		
The transmission line between Buronga and Broken Hill is ageing and requires a better backup power solution as it is more frequently shut down for maintenance or upgrade.	Broken Hill City Council, p. 2	The assessment against the reliability standard requires a probabilistic assessment of outages. There are currently no asset condition issues with the Buronga-Broken Hill line that would lead to an assumption of increasing an probability of outages.
With the aging nature of the transmission line between Buronga and Broken Hill it would seem logical that the reliability solution in Broken Hill will be called upon more frequently as more preventive and reactive maintenance on the line is performed. The PADR does not articulate what changes will be made to the existing diesel fuelled gas turbines to mitigate this situation and provide for potential increased operation in the future.	Hydrostor, p. 5	

Summary of comment(s)	Submitter(s)	Our response
Interaction with potential new mining loads at Broken Hill		
Two new mines are currently in the latter stages of development and represent the future of the mining industry in the Broken Hill region (Cobalt Blue and Hawsons Iron), these mines cannot be adequately supported by the diesel-fired turbines and we believe this aspect of the PADR analysis has not been adequately considered.	Broken Hill City Council, p. 2	See section 3.3.
Hydrostor is aware of new mining loads being progressed in the region and these developments will be hindered by not having access of a long-term, cost effective, predictable, and reliable supply of electricity. The Cobalt Blue and Hawsons Iron mines together will have an estimated load of between 180 MW to 190 MW. Both mines will produce metals that are in demand for the transaction to clean energy and lower emission industry. As neither of these loads are currently committed, Transgrid has not taken them onto account in the PADR conclusions.	Hydrostor, p. 6	
This jeopardises a new mine's ability to raise funding from investors as it increases their capital costs and can result in them failing to meet their stated sustainability goals.	Energy Estate, p. 3	
For greater clarity, the Hydrostor A-CAES solution has significant flexibility to readily supply this important load growth, a fact that is specifically recognized in the PADR, but unfortunately is not factored into the basic economic assessment of the diesel generators compared to the A-CAES alternative.	Hydrostor, p. 6	
Consistency with the AER guidelines in terms of the changed treatment of non-network option costs		

Summary of comment(s)	Submitter(s)	Our response
The RIT-T guidelines are clear that a proponent should rely on the guidelines that were in effect when a RIT-T proponent initiated the RIT-T (i.e., the Project Specification Consultation Report or PSCR): *Each version of these RIT–T application guidelines will be effective from its effective date of issue, and RIT–T proponents should apply it as soon as practical. However, for compliance purposes concerning a RIT–T application, we will only have regard to the guidance that was in effect when a RIT–T proponent initiated the RIT–T in question. In this context, initiated means from the publication of a project specification consultation report*. [Page 8 Application guidelines | Regulatory investment test for transmission August 2020]. Transgrid released its PSCR in November 2019. The guidelines that were in effect at that time were the December 2018 Application Guidelines for the Regulatory Investment Test for Transmission. It is unclear then, why the AER required Transgrid to adopt the 2020 RIT-T Guidelines, especially as it has resulted in a different preferred option.	Hydrostor, p. 2	Transgrid clarified with the AER which guidance to apply for this RIT-T, and the AER was clear that we should apply its most recent guidance on the treatment of non-network options.
As highlighted in Hydrostor's submission, it is unclear to us why AER required Transgrid to adopt the 2020 RIT-T Guidelines when Transgrid released its PSCR in November 2019, especially as it has resulted in a different preferred option.	Energy Estate, p. 2	

Summary of comment(s)	Submitter(s)	Our response
The cost benefit analysis in the revised PADR includes costs incurred by consumers through regulated revenues as well as the costs incurred by the equity participants in Hydrostor. We submit this is a misapplication of the RIT-T guidelines. The purpose of the RIT-T is to mitigate the risk that consumers will pay for inefficient investments. As articulated by the COAG Energy Council in its 2017 review into the RIT-T: "*The RIT-T is designed to identify the most efficient regulated investment in transmission infrastructure, whether intra- or inter-regional in scale, and ultimately protect consumers from paying more than necessary for their supply of electricity…* … when not called upon to provide the reliability, the A-CAES asset, as well as additional stages of A-CAES capacity that would be paid for and used by Hydrostor's equity holders, will participate in and add liquidity to the NEM wholesale market. It is the wholesale market participant's success (or failure) in the wholesale market that determines the extent of the market facing benefits. This is a risk to be borne the wholesale market participant, not consumers. As such, we submit that the benefits in the RIT-T calculation, for the unregulated capacity in the A-CAES solution, should be based on the expected revenue streams from its operation in the market. Such consideration would actually provide greater consideration to near-term implementation of a larger-scale A-CAES solution (as contemplated in the PADR), and indeed would result in the truly lowest costs to consumers. It is the equity participants in Hydrostor who will take the risk in this investment (not consumers), and it is their assessment of the benefits (revenue streams) that should be considered. Afterall, the AER doesn't tell a solar or wind farm, battery or a gas-fired peaker whether they think it is going to be profitable or not.	Hydrostor, p. 4	The RIT-T requires costs and benefits to be assessed from a real resource cost perspective, as opposed to a revenue perspective (which is considered a 'transfer'). We consider the modelling in this PACR to be fully consistent with the requirements of the RIT-T and the AER Guidelines.
Consistency with the latest ISP		
Transgrid engaged EY to undertake market modelling to assess the wholesale market benefits, allowed under the RIT-T guidelines, expected to arise under each of the credible options. However, EY's market benefit report was not updated under the revised PADR. The report produced in August 2020 was based on the 2020 AEMO ISP central scenario.	Hydrostor, p. 5	

Summary of comment(s)	Submitter(s)	Our response
EY undertook market modelling for Transgrid to assess the wholesale market benefits, allowed under the RIT-T guidelines, expected to arise under each of the credible options. The report was produced in August 2020 and was not updated for the revised PADR issued in October 2021. We expect the draft 2022 ISP to be released in December 2021 will include very material changes from the 2020 ISP and this has been heralded in the updated IASR and today AEMO mentioned in a Clean Energy Council presentation that significant additional volumes of long duration storage will be required in the coming years.	Energy Estate, p. 3	
Since the completion of the EY report the NSW Government has released its Energy Roadmap (November 2020) and AEMO will release the draft 2022 ISP in December 2021. Hydrostor submits that the combined impact of these changes will substantially change the market benefits and the report should be updated.	Hydrostor, p. 5	