Maintaining reliable supply to Broken Hill

RIT-T – Project Specification Consultation Report

Region: South Western New South Wales

Date of issue: 8 November 2019

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Executive summary

TransGrid is applying the Regulatory Investment Test for Transmission (RIT-T) to options for maintaining reliable supply to Broken Hill. Publication of this Project Specification Consultation Report (PSCR) represents the first step in the RIT-T process.

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

The average electricity demand at Broken Hill substation is approximately 38 MW.

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

When Line X2 is out of service due to a planned or unplanned outage, electricity supply to Broken Hill is supported by two gas turbines owned by Essential Energy to avoid involuntary load shedding (these turbines each have a nameplate rating of 25 MW). TransGrid relies on these gas 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, Essential Energy's gas turbines allow TransGrid to operate its network so as not to expect more than 10 minutes of unserved energy (EUE) per year at average demand.[1]

Identified need: maintaining reliable supply to Broken Hill

Essential Energy has notified TransGrid of its decision to divest the gas turbines located at Broken Hill. If no action is taken by TransGrid, this will result in the required reliability of supply to Broken Hill not being maintained, and involuntary load shedding when Line X2 is on planned or unplanned outage.

TransGrid considers 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.

In order to efficiently avoid involuntary load shedding and meet the reliability standards TransGrid has adopted a two-step approach.

- **Step 1** – Establish a short-term non-network support solution, via an Expression of Interest (EOI) process. The EOI was issued in October 2019 with responses due in November 2019. This short-term non-network support solution will be required to be available:
  - immediately, and
  - until the long-term solution, which will be identified under this the RIT-T process is operational. This could be up to three years.
- **Step 2** – Establish a long-term solution via the RIT-T. This document is the first step in the RIT-T process, which will consider all credible long-term options including traditional network, innovative, and non-network solutions. It may take up to three years for the long-term solution identified under the RIT-T process to be operational.

TransGrid's revenue determination for the 2018-2023 regulatory control period includes a contingent project for the reliability of supply to Broken Hill. This contingent project is to provide additional capacity to supply

[1] 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

Broken Hill in an event that the total 220 kV and 22 kV load at Broken Hill exceeds the capacity of the back-up gas turbines owned by Essential Energy and EUE exceeds the allowance.

Credible options considered

TransGrid considers there are five types of credible long-term option that would meet the identified need from a technical, commercial, and project delivery perspective.

While the indicative cost estimates for these options are specified in Table E-1, more accurate figures from responses to this PSCR and the accompanying EOI will be used for the cost-benefit analysis in the Project Assessment Draft Report (PADR).

Table E-1: Summary of the long-term credible options, $2018-19

Option	Description	Estimated capital cost	Estimated annual operating cost	Estimated completion date
1	Network support service	To be estimated based on responses to the EOI	To be estimated based on responses to the EOI	To be estimated based on responses to the EOI
2	Acquire existing gas turbines from Essential Energy	To be estimated based on responses to the EOI	~$2 million to $10 million per year	To be estimated based on responses to the EOI
3	New gas turbines at Broken Hill	~$75 million (to be refined based on responses to the EOI)	~$2 million to $10 million per year	To be in-place by 2021/22
4	Establish a second single circuit 220 kV transmission line from Buronga to Broken Hill	~177 million[2]	~$10,000 to $35,000 per year	To be in-place by 2023/24
5	Local storage and grid stability devices that provide inertia and system strength at Broken Hill	~$60 million to $350 million	To be estimated based on responses to the EOI	2022/23, subject to EOI responses

[2] TransGrid, *Revised Regulatory Proposal 2018/19-2022/23*, available at: https://www.aer.gov.au/system/files/TransGrid%20-%20Revised%20Revenue%20Proposal%20-%201%20December%202017.pdf

Net market benefits of the options are planned to be assessed under three different scenarios

TransGrid has constructed three alternative scenarios that are planned to be used in the cost benefit assessment in the PADR – namely:

- a 'low benefit' scenario, involving a number of assumptions that give rise to a lower bound Net Present Value (NPV) estimate of the expected net market benefits, in order to represent a conservative future state of the world with respect to potential benefits that could be realised;
- a 'central' scenario, which consists of assumptions that reflect TransGrid's central set of variable estimates which, in TransGrid's opinion, provides the most likely scenario; and
- a 'high benefit' scenario – this scenario reflects an optimistic set of assumptions, which have been selected to investigate an upper bound on reasonably expected net market benefits.

A summary of the key variables in each scenario is provided in the table below.

Table E-2: Summary of scenarios

Variable / Scenario	Central	Low	High
Capital costs	Base estimate	Base estimate + 25%	Base estimate - 25%
Involuntary load shedding	Based on POE50 demand forecast	Based on POE90 demand forecast	Based on POE10 demand forecast
VCR	Expected to be based on the AER determined VCR values (to be published by 31 December 2019)	Expected to be a lower bound based on the level of confidence in the AER determined VCR values	Expected to be an upper bound based on the level of confidence in the AER determined VCR values
Discount rate	5.9%[3]	8.95%	2.85%

TransGrid considers that the central scenario is most likely since it is based primarily on a set of expected assumptions. TransGrid proposes to therefore assign this scenario a weighting of 50 per cent, with the other two scenarios being weighted equally with 25 per cent each.

Submissions and next steps

The purpose of this PSCR is to set out the reasons TransGrid proposes that action be undertaken, present the options that address the identified need, outline the technical characteristics that non-network options would need to provide, and allow interested parties to make submissions and provide input to the RIT-T assessment.

Alongside this document, TransGrid has released an EOI to provide additional detail on the technical requirements for network and non-network options.

TransGrid welcomes written submissions on materials contained in this PSCR and the accompanying EOI. Submissions are particularly sought on the credible options presented and from potential proponents of non-

[3] Electricity Networks Association. *"RIT-T Economic Assessment Handbook."* Melbourne: Electricity Networks Association, 2019. https://www.energynetworks.com.au/sites/default/files/ena_rit-t_handbook_15_march_2019.pdf

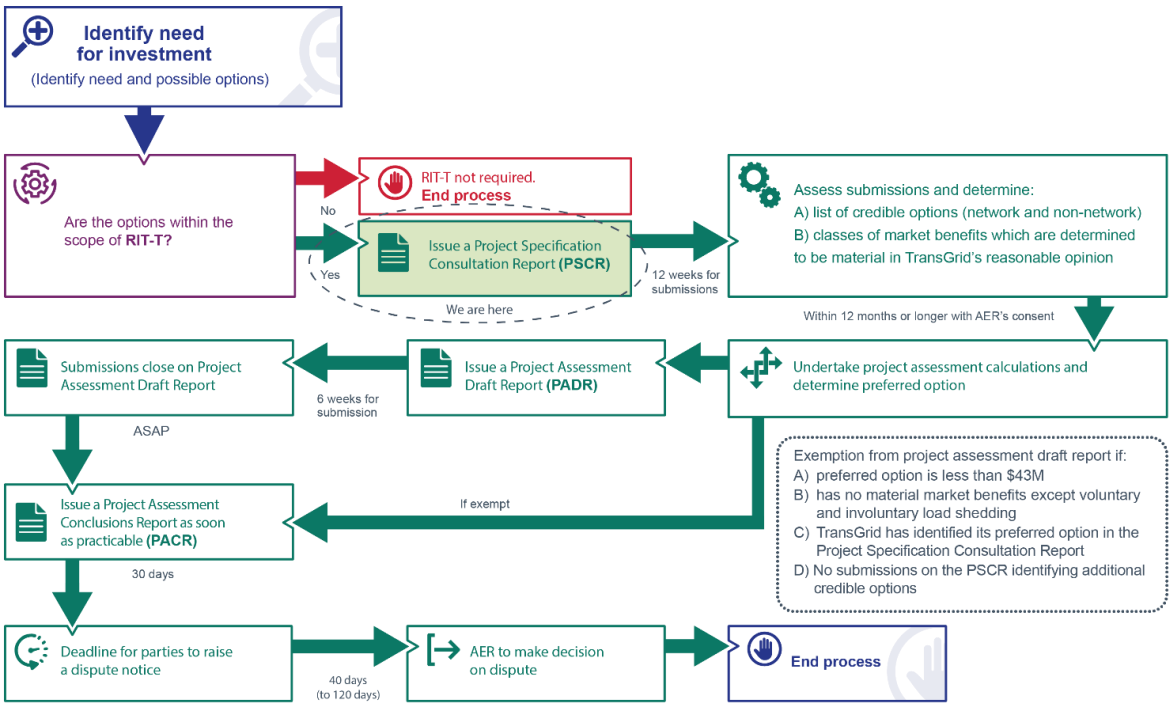
network options that could meet the technical requirements set out in this PSCR. Submissions are due on 31 January 2020.

Submissions should be emailed to TransGrid's Regulation team via regulatory.consultation@transgrid.com.au.[4] In the subject field, please reference 'PSCR Broken Hill reliability project.'

At the conclusion of the consultation process, all submissions received will be published on the TransGrid's website. If you do not wish for your submission to be made public, please clearly specify this at the time of lodgement.

The next formal stage of this RIT-T is the publication of a PADR. The PADR will include the full quantitative analysis of all credible options and is expected to be published in early 2020.

Figure E-1: This PSCR is the first stage of the RIT-T process[5]



[4] TransGrid is bound by the Privacy Act 1988 (Cth). In making submissions in response to this consultation process, TransGrid will collect and hold your personal information such as your name, email address, employer and phone number for the purpose of receiving and following up on your submissions. If you do not wish for your submission to be made public, please clearly specify this at the time of lodgement. See section 1.2 for more details.

[5] AER, *Final determination on the 2018 cost thresholds review for the regulatory investment tests,* available at: https://www.aer.gov.au/communication/aer-publishes-final-determination-on-the-2018-cost-thresholds-review-for-the-regulatory-investment-tests

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1. Introduction

TransGrid is applying the Regulatory Investment Test for Transmission (RIT-T) to long-term options for maintaining reliable supply to Broken Hill. Publication of this Project Specification Consultation Report (PSCR) represents the first step in the RIT-T process.

Broken Hill is located in the far west of New South Wales and is part of TransGrid's 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 gas turbines (owned by Essential Energy) to avoid involuntary load shedding. TransGrid relies on these gas turbines (25 MW nameplate rating each) 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, Essential Energy's gas turbines allow TransGrid to operate its network so as not to expect more than 10 minutes of unserved energy (EUE) per year at average demand.[6]

Essential Energy has notified TransGrid of its decision to divest the gas turbines located at Broken Hill. If no action is taken by TransGrid, this will result in the required reliability of supply to Broken Hill not being maintained, and involuntary load shedding when Line X2 is on planned or unplanned outage.

TransGrid has initiated a separate EOI process to establish a short-term non-network support solution to avoid involuntary load shedding and meet the reliability standards at Broken Hill. Responses are due in November 2019. The intention is that the short-term option will be available until the long-term solution, identified under this the RIT-T process, is operational.

This document is the first step in the RIT-T process to identify the long-term option to maintain the required reliability of supply at Broken Hill, in light of the existing gas turbines no longer being available to provide back-up capacity.

TransGrid's revenue determination for the 2018-2023 regulatory control period includes a contingent project for the reliability of supply to Broken Hill. This contingent project is to provide additional capacity to supply Broken Hill in an event that the total 220 kV and 22 kV load at Broken Hill exceeds the capacity of the back-up gas turbines owned by Essential Energy and EUE exceeds the allowance.[7]

1.1 Purpose

The purpose of this PSCR is to:

- set out the reasons why TransGrid proposes that action be undertaken (that is, the 'identified need');
- present the options that TransGrid currently considers address the identified need;
- outline the technical characteristics that non-network options would need to provide; and
- allow interested parties to make submissions and provide input to the RIT-T assessment.

Together with this document, TransGrid has released an Expression of Interest (EOI) to provide additional detail on the technical requirements for network and non-network options and seeks submissions from proponents of these options.

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6 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

7 TransGrid, *Revised Regulatory Proposal 2018/19-2022/23*, available at: https://www.aer.gov.au/system/files/TransGrid%20-%20Revised%20Revenue%20Proposal%20-%201%20December%202017.pdf

1.2 How to make a submission and next steps

TransGrid welcomes written submissions on materials contained in this PSCR and the accompanying EOI. Submissions are due on 31 January 2020.

Submissions should be emailed to TransGrid's Regulation team via regulatory.consultation@transgrid.com.au.[8] In the subject field, please reference 'PSCR Broken Hill reliability project.'

At the conclusion of the consultation process, all submissions received will be published on the TransGrid's website. If you do not wish for your submission to be made public, please clearly specify this at the time of lodgement.

The next formal stage of this RIT-T is the publication of a PADR. The PADR will include the full quantitative analysis of all credible options and is expected to be published in early 2020.

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2. The identified need

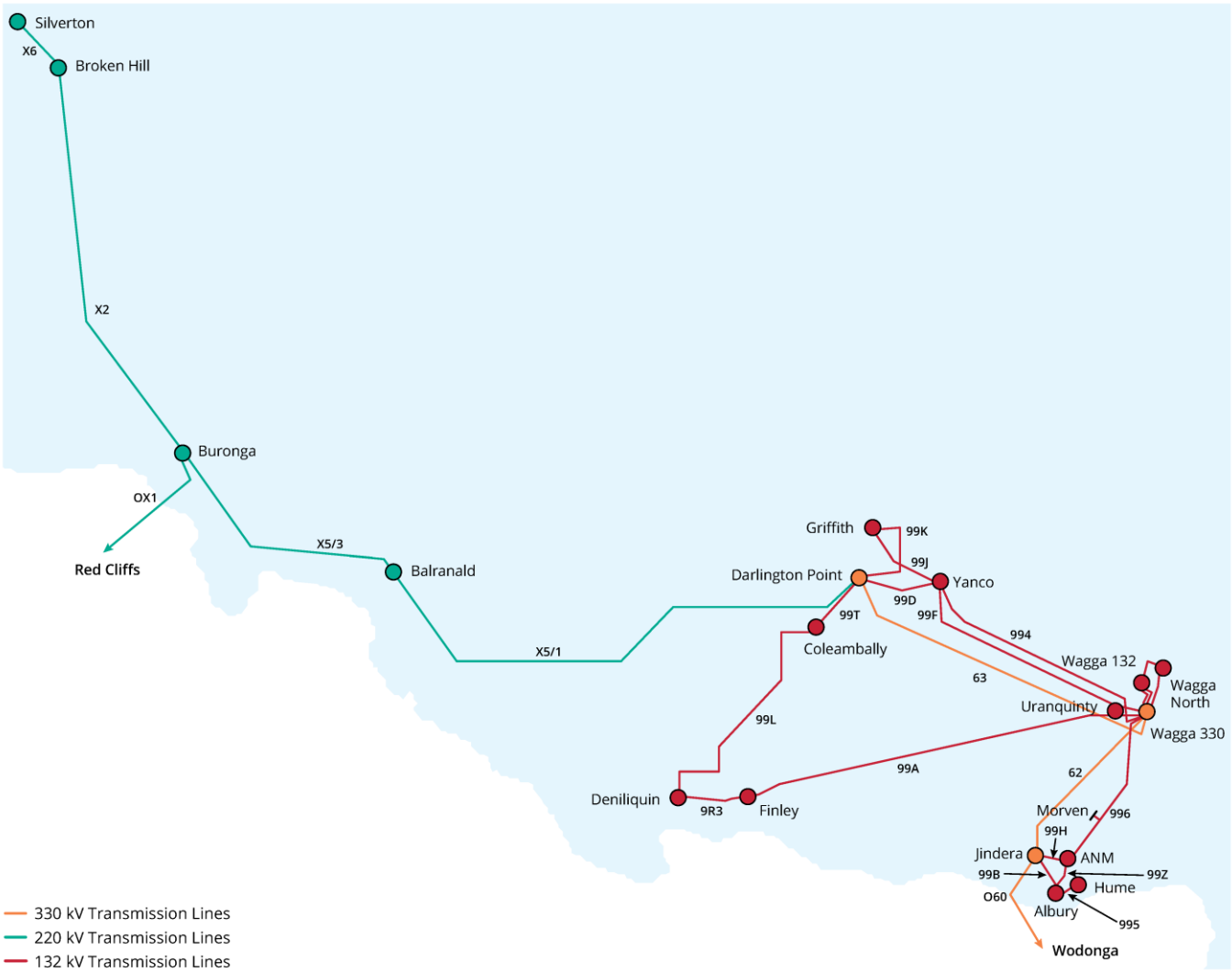
This section outlines the identified need for this RIT-T, as well as the assumptions and data underpinning it. It first sets out useful background on the current Broken Hill electricity supply arrangements.

2.1 Background to 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.

The current electricity network supplying Broken Hill is shown in Figure 2-1 below.

Figure 2-1: South western NSW transmission network



The average electricity demand at Broken Hill substation is approximately 38 MW.[9]

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

[9] 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 gas turbines that run on diesel fuel.[10]

These gas 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.

TransGrid has relied on these gas turbines to meet its obligations under NSW Electricity Transmission reliability standards as determined by IPART.

The reliability standards applicable to Broken Hill are set out in Table 2-1 below and currently require TransGrid to reliably supply the load at Broken Hill and maintain less than 10 minutes of EUE at average demand.[11]

Table 2-1: IPART reliability standards applicable to Broken Hill from 2018/19 onward

Broken Hill	Redundancy category [12]	Average demand (MW)	Unserved energy allowance (minutes)	Estimated unserved energy allowance (MWh)
Broken Hill 220 kV	1	16.4 MW	10 minutes (grouped)	2.8 MWh
Broken Hill 22 kV	1	21.6 MW		3.0 MWh
Total	1	38.0 MW	10 minutes	5.8 MWh

2.2 Description of the 'identified need'

Essential Energy has notified TransGrid of its decision to divest the gas turbines located at Broken Hill.[13]

If no action is taken by TransGrid, this will result in the required reliability of supply to Broken Hill not being maintained, and involuntary load shedding when Line X2 is on planned or unplanned outage.

In light of the forthcoming unavailability of the gas turbines, TransGrid is considering options and alternative solutions to provide back-up and reliable supply to Broken Hill for the future that is consistent with the NSW Electricity Transmission Reliability and Performance Standards.

TransGrid considers this a 'reliability corrective action' under the RIT-T as the proposed investment is for the purpose of meeting externally-imposed regulatory obligations and service standards.

[10] 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.

[11] 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

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

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

2.3 Assumptions underpinning the identified need

This section sets out a number of key assumptions TransGrid consider underpin the identified need. In particular, it outlines assumptions behind TransGrid's assessment that a reliability corrective action is required.

2.3.1 Maintaining compliance with Performance and reliability standards

TransGrid is currently able to meet the performance and reliability standards applicable for Broken Hill by utilising Essential Energy's gas turbines for back-up generation during an outage of Line X2.

TransGrid's modelling shows that, in the absence of an alternative option, the removal of gas turbines from service would give rise to EUE larger than the allowance under the IPART reliability standards, as shown in Table 2-2 below.

The EUE due to unplanned outages of Line X2 is calculated by taking the annual energy consumption at Broken Hill and multiplying it by the probability of trip of the line (see Table 2-3). This results in approximately 455 MWh, which is valued at approximately $15.5 million per annum using a VCR of $34,000/MWh.[14]

Table 2-2: EUE in the absence of gas turbines at Broken Hill

Broken Hill	Average demand (MW)	Unserved energy allowance (minutes)	Estimated Unserved energy allowance (MWh)	EUE without gas turbines (minutes)	EUE without gas turbines (MWh)
Broken Hill 220 kV	16.4 MW	10 minutes	2.8 MWh	353 minutes	205 MWh
Broken Hill 22 kV	21.6 MW		3.0 MWh	432 minutes	250 MWh
Total	38.0 MW	10 minutes	5.8 MWh	784 minutes	455 MWh

In addition, TransGrid expects demand at Broken Hill to increase in line with current growth rates, meaning that the value of this EUE going forward is expected to increase.

2.3.2 Line X2 technical parameters

As the planned or unplanned unavailability of Line X2 drives involuntary load shedding estimates, the forecast EUE is informed by the life cycle failure rate of Line X2, which is a function of the line's age, length, and average failure duration. These parameters are set out in Table 2-3.

Table 2-3: Failure rate and duration for Line X2

Average life cycle failure rate	Length of Line X2	Average failure duration	Unavailability per annum
0.06 per 100 km per annum	259.5 km	102.6 hours/event	0.183 per cent

[14] This VCR is to be treated as indicative and is based on the 2014 AEMO estimated VCR values. The economic assessment in the PA DR intends to use the VCR values currently being developed and consulted on by the AER (expected to be published by 31 December 2019).

Over the last ten years, unplanned outages have lasted for between 14 to 192 hours. However, on average, the expected duration of unplanned outage (mean time to repair) of Line X2 is 102.6 hours. Meanwhile, the expected duration of each planned outage (maintenance outage) is shorter (12 hours).

2.3.3 No other source of back-up supply is currently available

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

3. Options that meet the identified need

TransGrid has identified five 'types' of options that include both network and non-network approaches to meeting the identified need.

While TransGrid has provided indicative cost estimates for some of the network and non-network options that address the identified need (Table 3-1), more accurate figures will be developed from responses to this PSCR and the accompanying EOI, which will inform the cost-benefit analysis in the PADR.

Table 3-1: Summary of the credible options, $2018-19

Option	Description	Estimated capital cost	Estimated annual operating cost	Estimated completion date
1	Network support service	To be estimated based on responses to the EOI	To be estimated based on responses to the EOI	To be estimated based on responses to the EOI
2	Acquire existing gas turbines from Essential Energy	To be estimated based on responses to the EOI	~$2 million to $10 million per year	To be estimated based on responses to the EOI
3	New gas turbines at Broken Hill	~$75 million (to be refined based on responses to the EOI)	~$2 million to $10 million per year	To be in-place by 2021/22
4	Establish a second single circuit 220 kV transmission line from Buronga to Broken Hill	~177 million[15]	~$10,000 to $35,000 per year	To be in-place by 2023/24
5	Local storage and grid stability devices that provide inertia and system strength at Broken Hill	~$60 million to $350 million	To be estimated based on responses to the EOI	2022/23, subject to EOI responses

Section 4 provides additional details on the technical capabilities that non-network solutions would need to provide to be able to address the identified need considered in this RIT-T.

Combinations of these options may be further evaluated at the PADR stage, if they arise from this consultation.

None of the credible options listed above is expected to have a material inter-regional impact.

[15] TransGrid, *Revised Regulatory Proposal 2018/19-2022/23*, available at: https://www.aer.gov.au/system/files/TransGrid%20-%20Revised%20Revenue%20Proposal%20-%201%20December%202017.pdf

3.1 Option 1 – Network support service

Option 1 involves a network support arrangement (or arrangements) to provide back-up supply for Broken Hill to meet reliability standards and satisfy the identified need. Option 1 is a non-network option where these services would be provided by a third-party by way of a network support contract with TransGrid.

While TransGrid considers that the most likely approach to Option 1 would be to contract for diesel generators that would replace the existing gas turbines at Broken Hill, there are a range of other technologies that could provide the required support. For example:

- generation (both embedded and grid-connected), which may include the existing gas turbines at Broken Hill if purchased by a third party;
- bulk energy storage, including aggregated battery systems, which injects power into the grid when required; and
- demand management.

The service would need to be delivered and commissioned prior to Essential Energy's gas turbines becoming unavailable. Together with this document, TransGrid has published an EOI to seek submissions from interested parties to provide this service.

3.2 Option 2 – Acquire existing gas turbines from Essential Energy

Option 2 involves the acquisition by TransGrid of the existing gas turbines at Broken Hill from Essential Energy. This option is distinct from Option 1 in that it is assumed that the existing gas turbines become directly owned by TransGrid, rather than being purchased by a third party who may then use them to offer network support services to TransGrid.

Essential Energy has indicated its intention to divest the existing gas turbines. TransGrid expects that Essential Energy may submit a proposal for TransGrid to purchase the existing gas turbines, in response to the EOI being issued alongside this PSCR. TransGrid may also seek an initial engineering assessment of the condition of the gas turbines in order to develop a reasonable cost estimate (including costs such as refurbishment or replacement at appropriate times) of this option for the purposes of the PADR assessment and to ensure it is technically feasible (given the age and condition of the assets).

3.3 Option 3 – New gas turbines at Broken Hill

Option 3 involves the commissioning of new gas turbines at Broken Hill. This option is again distinct from Option 1 in that it is assumed that this new source of back-up supply is network owned.

Potential new generators may be able to utilise the latest gas turbine technologies, which could improve fuel efficiency and response times (compared to the existing turbines).

Together with this document, TransGrid has published an EOI to seek submissions from interested parties to supply and install these assets.

3.4 Option 4 – Establish a second single circuit 220 kV transmission line

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 is expected to cost around $177 million and the project could be delivered in 36 months. Annual operating costs are estimated to be $10,000 to $35,000 per year.

3.5 Option 5 – Establish local energy storage and grid stability devices

Option 5 involves the installation of energy storage systems and grid stability devices to provide back-up to Broken Hill when Line X2 is unavailable. Depending on the ultimate combination of solutions, Option 5 may involve both network assets and network support agreements.

Specifically, initial thinking is that Option 5 could involve:

- installation of bulk energy storage between 120 MWh and 650 MWh[16] (depending on the level of demand management available) with associated balance of plant, including associated step-up transformers and switchbay (the bulk energy storage facility will need to be black start capable, have the ability to energise transformers in the area, and be able to charge/store energy at the same rate it can be discharged or faster);
- equipment to provide sufficient short-circuit power such that the short-circuit ratio (SCR) at the connection point is SCR ≥ 3[17] and to allow Silverton Wind Farm and Broken Hill Solar Plant to generate islanded, if the energy storage technology does not provide this natively;
- equipment or modifications to equipment at Silverton Wind Farm and Broken Hill Solar Plant;
- protection changes to TransGrid's and Essential Energy's relays;
- equipment to operate under low short-circuit ratio conditions;
- potential upgrades of existing network equipment if fault currents increase beyond their rating; and
- equipment to provide required inertia.

Equipment installed would provide energy storage when Broken Hill substation is connected to the grid and back-up supply when Line X2 is not available.

While the indicative capital cost range shown in Table 3-1 ranges from $60 million to $350 million (based on a high-level assessment of such an option by TransGrid), this is expected to be refined in the PADR based on responses to this PSCR and the accompanying EOI.

TransGrid intends to approach a number of stakeholders, funding bodies, and governments that may assist with developing innovative solutions like Option 5 over traditional network solutions.

TransGrid invites interested parties to respond to the EOI that was published with this report.

[16] The amount required will depend on the amount of demand management available.

[17] AEMO, *System Strength Impact Assessment Guidelines*, available at: https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/System-Strength-Impact-Assessment-Guidelines

3.6 Options considered but not progressed

TransGrid has also considered whether two other network options would meet the identified need. The reasons these options have not been progressed any further are summarised in Table 3-2.

Table 3-2: Options considered but not progressed

Option	Reason(s) for not progressing
Double circuit 330 kV line to Mount Piper	Costs estimated are significantly higher than Option 3 due to the distance without any additional benefits. Accordingly, these two options are not considered to be commercially feasible.
HVDC link to Mount Piper	

4. Non-network options

Consistent with the requirements of the RIT-T, the required technical characteristics for non-network options are set out in this section. In particular:

- Section 4.1 outlines general information for non-network options;
- Section 4.2 provides information on generation or energy storage requirements;
- Section 4.3 provides information on load curtailment requirements; and
- Section 4.4 provides information on how existing renewable generation could assist.

Interested parties should also refer to the accompanying EOI for information required to be provided by proponents of non-network options. TransGrid requires parties to submit offers that satisfy, or contribute to satisfying, the identified requirements for non-network options in a spreadsheet format provided in the EOI.

In addition to formally seeking responses to this PSCR and the EOI, TransGrid strongly encourages that potential proponents of non-network solutions to contact TransGrid ahead of preparing a submission.

4.1 General information for non-network options

The required scope of non-network options to meet the identified need is for the provision of network support of up to 50 MW and 650 MWh that serves to reduce involuntary load shedding.

TransGrid considers possible non-network options could include:

- generation (both embedded and grid-connected), which may include the existing gas turbines at Broken Hill if purchased by a third party;
- bulk energy storage, including aggregated battery systems, which injects power into the grid when required; and
- demand management.

As an unplanned outage of Line X2 can happen at any time with little or no notice, the back-up supply solution would be required to deliver at least 650 MWh of energy to meet the reliability standard. That is, for solutions comprising energy storage only, a minimum of 650 MWh (less any load curtailment from demand reductions) of energy would need to be stored at all times in order to be available in an event of an unplanned outage. Notwithstanding this, the back-up supply solution may comprise part of a larger solution that is also used for other purposes, including the provision of market services, at other times.

The sections below provide information to assist non-network proponents formulate responses to this PSCR.

4.1.1 Location of the required network support

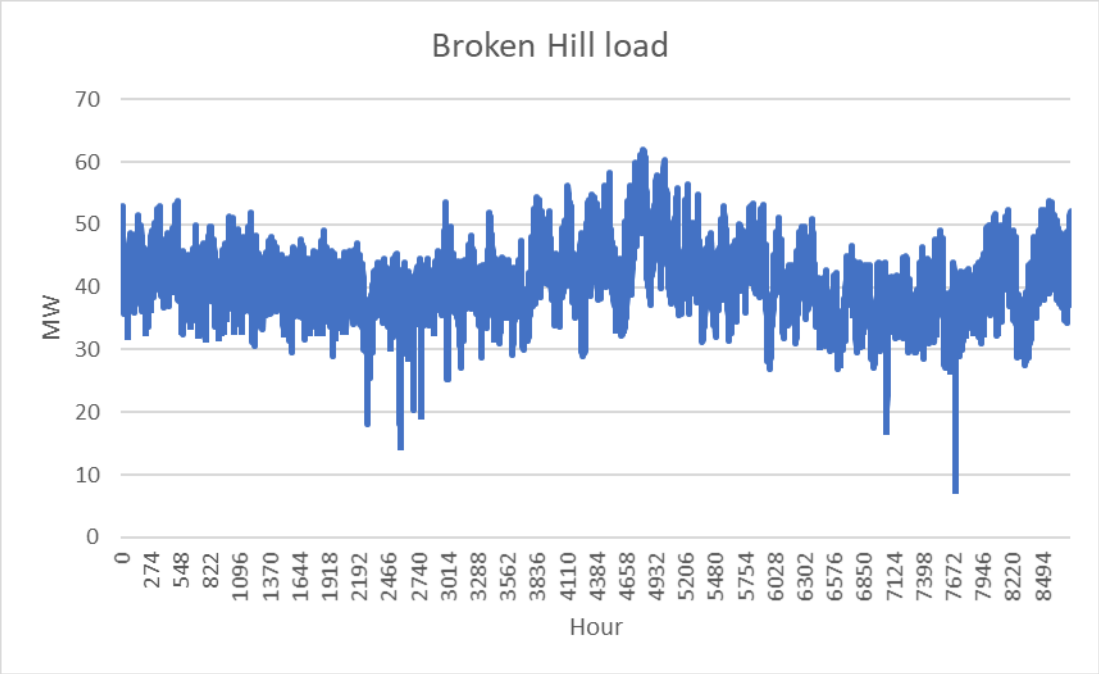
TransGrid is seeking network support located in the Broken Hill area. This includes all loads that are supplied by Broken Hill substation at 220 kV or 22 kV including suburbs in the area of impact, ie:

- Menindee;
- Mount Gipps;
- Pinnacles Place;
- Sunset Strip; and
- Wilcannia.

4.1.2 Load profile

The average demand at Broken Hill is approximately 38 MW. The maximum demand is approximately 62 MW. Figure 4-1 shows Broken Hill load profile over financial year 2018-19.

Figure 4-1: Broken Hill load profile, financial year 2018-19



4.1.3 Indicative capacity and energy volume

The size of the combined back-up supply should be at least as large as the capacity required to reduce the expected unserved energy and meet the reliability standard, resulting from either planned or unplanned outages. This forms the basis of the energy volume required to meet the reliability standard stipulated by IPART.

Over the last ten years, outages have lasted for 14 to 192 hours while the expected duration of each unplanned outage on this transmission line is 102.6 hours. Meanwhile, the expected duration of each planned outage for scheduled maintenance is shorter at 12 hours. As the average duration of repair is greater than the duration of maintenance, sizing the non-network option for unplanned outages is sufficient to also cover maintenance outages.

The capacity and energy volume requirements of the combined back-up supply solution are described in Table 4-1.

These requirements may be reduced with load curtailment.

Cost-effective solutions that have flexibility (option to expand) to accommodate new spot loads are preferable.

Table 4-1: Combined Requirements: Capacity and Energy

Capacity (MW)	Energy volume requirement per outage (MWh)
50	650

4.1.4 Availability and timing

To maintain reliable supply, network support would be required to provide a back-up supply for the duration of the outage. Unlike other demand management projects, network support will be required to be available all year round, irrespective of time of day or day type. Table 4-2 summarises these requirements.

Table 4-2: Technical requirements for non-network requirements

Time scale	Target
Time of year	All year round
Time of day	All day
Day type	Any day
Duration	102.6 hours per outage on average, up to 650 MWh of energy output, up to 50 MW of power output
Probabilistic unavailability of the line	0.183% (or ~16 hours per annum)
Start-up time [a]	49 minutes

[a] supply to load must be restored within this timeframe to meet the reliability standards.

4.2 Generation or energy storage requirements

TransGrid will consider solutions that meet at least one of the requirements listed in Table 4-3. Proponents' solutions can partially or completely meet these requirements, however, where TransGrid deems that there is shortfall in these capabilities, the cost of a technology that fulfils that shortfall will be included in the cost of the option. For example, for solutions that lack inertia or system strength, a device such as a synchronous condenser will be added to that solution's total cost.

Table 4-3: Generation and energy storage requirements

Generation requirements	Description
Black start capable	The non-network options must be able to start themselves using a power source outside the network and energise Broken Hill loads progressively. The required start-up time for the generation to meet TransGrid's reliability standard is 49 minutes. A seamless transition from grid-supply to back-up supply, and vice versa would provide the best outcome for the consumer. The switching scheme will be considered on a cost-benefit basis, in addition to meeting the reliability standard requirement.
Grid-forming capable	Provide a grid reference for frequency (50 Hz) and voltage control in a grid-islanded system during outages of Line X2.[18] > The preferred control system would have grid-forming and grid-following capability. The control system would use the same operating mode in both grid-connected and grid-islanded scenarios

[18] For power electronics based technologies (inverters), please provide details of the manufacturer, model, and converter design that differs from traditional grid-following inverters.

Generation requirements	Description
	> The preferred control system would use the same operating mode for voltage regulation functionality.
Provide inertia or synthetic inertia	The ability to resist changes in frequency in grid-island mode.[19] This contributes to maintaining good frequency control in the grid-island. The potential solutions that lack this capability will be supplemented with the cost of technologies that can provide this capability.
Provide Short-Circuit Current	Provide a minimum of 24.5 MVA (643 Amps for 5 seconds at 22 kV) of short-circuit power (3-phase fault current), in order for the existing protection systems (at both TransGrid and Essential Energy) to function correctly. Alternatively, changes to existing protection equipment to operate in a low fault level environment may be acceptable, subject to technical feasibility.

4.3 Load curtailment requirements

Any customer loads that are contracted to disconnect from Broken Hill substation during outages of Line X2 will reduce both the capacity and energy volume requirements of the back-up supply solution as stated in section 4.1.3.

4.4 Additional requirements for renewables to operate in a grid-island

Additional requirements to allow renewable generation to operate in a grid-island following an outage of Line X2 are set out in Table 4-4.

Table 4-4: Additional requirements to allow renewables to operate in a grid island

Additional requirements	Description
Energise transformers	The largest transformer at both renewable generators is at Silverton Wind Farm, which has a maximum output of 200 MW.
Provide system strength	The renewable generators at Broken Hill are presently not able to operate in a grid-island. The inverters at these solar and wind farms provide low levels of short-circuit power under short-circuit (fault) conditions. The backup supply solution must provide a Short Circuit Ratio (SCR ≥ 3), or as otherwise demonstrated stable under all system conditions by EMT modelling, in order to allow Silverton Wind Farm and Broken Hill Solar Plant to operate in a grid-island.[20] The total amount of generation that can operate at any one time is dependent on matching the load profile of the grid-island. For power electronics based technologies, please provide the duration of the expected the fault current contribution.
Energy storage	> The ability for energy storage to absorb renewable generation, in excess of the Broken Hill grid-island load that would otherwise be spilt. Alternatively, energy storage could be

[19] Mode of operation when there is no frequency reference available.

[20] For power electronics based technologies, please provide the duration of the expected fault current contribution.

Additional requirements	Description
	charged from the grid when Broken Hill is not operating as a grid-island in anticipation of an outage, or from an energy resource that may be decoupled from the grid. > Be able to charge/store energy at the same rate it can be discharged or faster. > The ability to inject power into the grid during variable deficits between intermittent generation and load. > A minimum of 650 MWh (less any load curtailment from demand reductions and minimum charge) of energy will need to be stored at all times, in anticipation of an outage.
Other considerations	> Protection changes to TransGrid's, Essential Energy's, Broken Hill Solar Plant's, and Silverton Wind Farm's equipment in the area. > Changes to allow Silverton Wind Farm and Broken Hill Solar Plant to provide partial output in a grid-island. > Any associated balance of plant, transformers, switchbays > Design, component testing, civil work, delivery, installation, commissioning > Equipment (transmission, distribution, and customer) that will need to be replaced to operate in a high or low fault level environment.

5. Materiality of market benefits

5.1 Changes in involuntary load shedding are expected to be material

TransGrid considers that the only category of market benefit that is likely to be material is changes in involuntary load shedding. Other categories of market benefits prescribed in the NER are not considered material for this RIT-T at this stage.[21]

As part of the PADR assessment, TransGrid proposes to estimate the avoided EUE at Broken Hill and surrounding areas under each of the credible options, compared to the base case. This will include both planned and unplanned outages and will be valued at the Value of Customer Reliability (VCR), as outlined in section 6.3 below.

5.2 Wholesale electricity market benefits are not material

The AER has recognised that if the credible options considered will not have an impact on the wholesale electricity market, then a number of classes of market benefits will not be material in the RIT-T assessment, and so do not need to be estimated.[22]

While both the Broken Hill Solar Plant and Silverton Wind Farm are connected to the Broken Hill substation, and would not be able to dispatch to the NEM during a planned or unplanned outage of Line X2 under the base case, we do not intend to model any consequent impact on the wholesale market since these benefits are not expected to be materially different across the options. While Option 3 would likely enable these generators to dispatch to the NEM more than under the other options, the associated market benefits are not expected to be commensurate with Option 3's significantly greater cost.

TransGrid therefore considers that the following classes of market benefits are not material for this RIT-T assessment:

- changes in fuel consumption arising through different patterns of generation dispatch;
- changes in price-responsive voluntary load curtailment (since there is no significant impact on pool price);
- changes in costs for parties, other than for TransGrid (since there will be no deferral of generation investment);
- changes in ancillary services costs;
- competition benefits; and
- Renewable Energy Target (RET) penalties.

5.3 No other categories of market benefits are material

In addition to the classes of market benefits listed above, NER clause 5.16.1(c)(4) requires TransGrid to consider the following classes of market benefits, listed in Table 5-1, arising from each credible option.

The same table sets out the reason TransGrid considers these classes of market benefits to be immaterial.

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[21] The NER requires that all categories of market benefits 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 – NER clause 5.16.1(c)(6). Under NER clause 5.16.4(b)(6)(ii), the PSCR should set out the classes of market benefits that the NSP considers are not likely to be material for a particular RIT-T assessment.

[22] AEMO, *Power System Security Guidelines*, available at: https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Power_System_Ops/Procedures/SO_OP_3715---Power-System-Security-Guidelines.pdf

Table 5-1: Reasons non-wholesale electricity market benefits categories are considered immaterial

Market benefits	Reason
Differences in the timing of expenditure	Options considered will provide an alternative to Line X2 in supplying Broken Hill to meet reliability requirements and are unlikely to affect decisions to undertake unrelated expenditure in the network. Consequently, material market benefits will neither be gained nor lost due to changes in the timing of expenditure from any of the options considered.
Changes in network losses	For all options except Option 3, there will not be any material change to network losses as there is no change to the capacity of the line or the destination of the line. For Option 3, TransGrid estimates that the expansion of the transmission network's capacity to and from Broken Hill will not generate material changes in network losses.
Option value	TransGrid notes that option value is likely to arise where there is uncertainty regarding future outcomes, the information that is available is likely to change in the future, and the credible options considered by the TNSP are sufficiently flexible to respond to that change.[23] Changes in future demand levels are not relevant for this RIT-T, since the need for and timing of the required investment is being driven by asset availability rather than future demand growth. Additionally, a significant modelling assessment would be required to estimate the option value benefit but it would be disproportionate to potential additional benefits for this RIT-T. TransGrid is therefore not intending to estimate any additional option value benefit.

[23] This is consistent with the AER's view, see: AER, *Regulatory Investment Test for Transmission Application Guidelines,* December 2018, available at: . https://www.aer.gov.au/system/files/AER%20-%20Final%20RIT-T%20application%20guidelines%20-%2014%20December%202018_0.pdf

6. Overview of the assessment approach

This section outlines the approach that TransGrid is proposing to apply in assessing the net benefits associated with each of the credible options.

6.1 Assessment period and discount rate

The analysis presented in this RIT-T will consider a 20-year period, from 2019/20 to 2039/40. TransGrid considers that a 20-year period takes into account the size, complexity and expected lives of the options and provide a reasonable indication of the costs and benefits over a long outlook period. Since the capital components have asset lives greater than 20 years, TransGrid will take a terminal value approach to ensure that the capital costs of long-lived assets are appropriately captured in the 20-year assessment period.

TransGrid will adopt a central real, pre-tax 'commercial'[24] discount rate of 5.9 per cent as the central assumption for the NPV analysis presented in this report. TransGrid considers that this is a reasonable contemporary approximation of a commercial discount rate, consistent with the RIT-T.

TransGrid will also test the sensitivity of the results to discount rate assumptions. A lower bound real, pre-tax discount rate of 2.85 per cent equal to the latest AER Final Decision for a TNSP's regulatory proposal at the time of preparing this PSCR,[25] and an upper bound discount rate of 8.95 per cent (a symmetrical adjustment upwards) will be investigated.

6.2 Approach to estimating project costs

TransGrid's initial cost estimates presented in this PSCR have been at a high level based on experience from previous projects involving similar options or based on publicly available information. It is intended that cost estimates will be further refined in the PADR stage. This process will be informed by responses to the EOI and further detailed costing by TransGrid with the objective to achieve costs that are estimated to be within +/- 25 per cent of the actual cost.

6.3 Three different scenarios will be modelled to address uncertainty

RIT-T assessments will be based on cost-benefit analysis that includes assessment under reasonable scenarios which are designed to test alternate sets of key assumptions and their impact on the ranking and feasibility of options.

TransGrid proposes to adopt three alternative scenarios in the PADR assessment – namely:

- a 'low net economic benefits' scenario, involving a number of assumptions that gives a lower bound and conservative estimates of net present value of net economic benefits
- a 'central' scenario which consists of assumptions that reflect TransGrid's central set of variable estimates that provides the most likely scenario
- 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.

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[24] The use of a 'commercial' discount rate is consistent with the RIT-T and is distinct from the regulated cost of capital (or 'WACC') that applies to network businesses like TransGrid.

[25] See TasNetworks' Post-tax Revenue Model (PTRM) for the 2019-24 period, available at: https://www.aer.gov.au/networks-pipelines/determinations-access-arrangements/tasnetworks-determination-2019-24

A key expected driver of the net market benefits is likely to be the VCR. We are proposing to use the VCR estimates currently being developed and consulted on by the AER in the PADR assessment, which are expected to be published by 31 December 2019. If these estimates are not available, we propose to use the VCR values estimated by AEMO in 2014.[26]

A summary of the key variables in each scenario is provided in Table 6-1.

Table 6-1: Summary of scenarios

Variable	Central	Low net economic benefits	High net economic benefits
Capital costs	Base estimate	Base estimate + 25%	Base estimate - 25%
Involuntary load shedding	Based on POE50 demand forecast	Based on POE90 demand forecast	Based on POE10 demand forecast
VCR	Expected to be based on the AER determined VCR values (to be published by 31 December 2019)	Expected to be a lower bound based on the level of confidence in the AER determined VCR values	Expected to be an upper bound based on the level of confidence in the AER determined VCR values
Discount rate	5.90%	8.95%	2.85%

TransGrid considers that the central scenario is most likely since it is based primarily on a set of expected assumptions. TransGrid has therefore assigned this scenario a weighting of 50 per cent, with the other two scenarios being weighted equally with 25 per cent each.

[26] https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Value-of-Customer-Reliability-review

Appendix A – Compliance checklist

This appendix sets out a compliance checklist which demonstrates the compliance of this PSCR with the requirements of clause 5.16.4(b) of the Rules version 125.

Rules clause	Summary of requirements	Relevant section(s) in PSCR
5.16.4 (b)	A RIT-T proponent must prepare a report (the project specification consultation report), which must include:	–
	(1) a description of the identified need;	2
	(2) the assumptions used in identifying the identified need (including, in the case of proposed reliability corrective action, why the RIT-T proponent considers reliability corrective action is necessary);	2.3
	(3) the technical characteristics of the identified need that a non- network option would be required to deliver, such as: (i) the size of load reduction of additional supply; (ii) location; and (iii) operating profile;	4
	(4) if applicable, reference to any discussion on the description of the identified need or the credible options in respect of that identified need in the most recent National Transmission Network Development Plan;	NA
	(5) a description of all credible options of which the RIT-T proponent is aware that address the identified need, which may include, without limitation, alterative transmission options, interconnectors, generation, demand side management, market network services or other network options;	3 & 4
	(6) for each credible option identified in accordance with subparagraph (5), information about: (i) the technical characteristics of the credible option; (ii) whether the credible option is reasonably likely to have a material inter-network impact; (iii) the classes of market benefits that the RIT-T proponent considers are likely not to be material in accordance with clause 5.16.1(c)(6), together with reasons of why the RIT-T proponent considers that these classes of market benefits are not likely to be material; (iv) the estimated construction timetable and commissioning date; and (v) to the extent practicable, the total indicative capital and operating and maintenance costs.	3, 4 & 5