Maintaining reliable supply to the North West Slopes area

RIT-T – Project Specification Consultation Report

Region: Northern New South Wales

Date of issue: 21 April 2021

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Executive summary

TransGrid is applying the Regulatory Investment Test for Transmission (RIT-T) to options for maintaining reliable supply to the North West Slopes area of northern New South Wales (NSW). Publication of this Project Specification Consultation Report (PSCR) represents the first step in the RIT-T process.

The latest demand forecasts for the North West Slopes indicate that electricity demand is expected to increase substantially in the area going forward. This is driven by a number of substantial industrial loads anticipated to connect, as well as underlying general load growth in Narrabri and Gunnedah.

TransGrid's power system studies forecast that the expected load growth will reach voltage stability and thermal limits on the 132 kV supply network in the North West Slopes area if action is not taken by 2024.

This RIT-T examines network and non-network options for relieving these constraints going forward to ensure compliance with the requirements of the NER and provide the greatest net benefit to the market.

The 'identified need' is to provide reliable supply to North West Slopes in light of the significant projected load growth

Schedule 5.1.4 of the NER requires us to plan and design equipment for voltage control to maintain voltage levels within 10 per cent of normal voltage.[1] The NER also requires the power system to be operated in a satisfactory operating state, which requires voltages to be maintained within these levels, both in normal operation and following any credible contingency event.[2]

TransGrid undertook planning studies that show that the current North West Slopes network will not be capable of supplying the combined increases in load in the area without breaching the NER requirements and that voltage-limited constraints will have to be applied in the 132 kV supply network if action is not taken.

Moreover, in addition to the longer-term voltage constraints identified, TransGrid's planning studies show that the increased demand will also lead to thermal constraints in the region, particularly during times of low renewable generation dispatch in the region.

If the longer-term constraints associated with the load growth in the North West Slopes are unresolved, it could result in the interruption of a significant amount of electricity supply under both normal and contingency conditions due to voltage and thermal limitations in the area.

TransGrid has therefore commenced this RIT-T to assess options to ensure the above NER requirements continue to be met in the North West Slopes with forecast demand increases.

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, i.e., Schedule 5.1.4 of the NER.

Four types of credible network options have been identified

TransGrid considers there are four broad types of credible network options that have the potential to meet the identified need from a technical, commercial, and project delivery perspective.

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1 These levels are specified in Clause S5.1a.4.

2 These requirements are set out in Clauses 4.2.6, 4.2.4 and 4.2.2(b) of the NER. The requirement for secure operation of the power system in Clause 4.2.4 requires the power system to be in a satisfactory operating state following any credible contingency event, that is, to maintain voltage within 10 per cent of normal voltage following the first credible contingency event.

TransGrid considers that each of the credible network options outlined in this PSCR requires the installation of a third 60 MVA 132/66 kV transformer at Narrabri due to the firm supply capacity of the existing transformers at this location being exceeded under all scenarios. This new transformer is estimated to cost between $20 million and $30 million and is assumed to be installed by 2024/25 for all options and scenarios.

Aside from the new 132/66 kV transformer at Narrabri, the credible network options differ in the near-term by where, how and when new capacity is added to the North West Slopes region. In particular, TransGrid currently considers there to be four broad types of credible option, which, outside of the common new transformer at Narrabri, centre on:

- uprating the existing line 969 from Tamworth to Gunnedah;
- installing new single or double circuit transmission lines between Tamworth and Gunnedah;
- rebuilding the existing line 969 from Tamworth to Gunnedah to be a double circuit line; and
- connecting to a potential new private transmission project in the Gunnedah area called the New England Transmission Infrastructure (NETI).[3]

The estimated scope, cost and delivery timelines for each option are set out in this PSCR.

The credible options outlined in this PSCR have been developed as part of TransGrid's long-term planning for the area and each involves a series of investments into the future. While this RIT-T will assess all stages of these options in order to identify the most efficient series of investments to meet network needs over the long-term, the immediate impact of this RIT-T will be TransGrid progressing the nearer-term stages of the ultimately preferred option (i.e., those expected to be required in the next five years). TransGrid anticipates that a separate RIT-T will be applied in the future to the later stages in order to determine whether they remain optimal.

Non-network solutions may also be able to form credible options for this RIT-T

TransGrid considers that non-network solutions may be able to form credible options for this RIT-T, either as standalone options or in combination with network options (or components of these options).

At this stage, TransGrid considers that possible solutions include but are not limited to:

- generation (both embedded and grid-connected); and
- energy storage (bulk or aggregated systems), including but not limited to:
  - sealed batteries;
  - flow batteries;
  - concentrated solar thermal with storage;
  - compressed air storage; and
  - pumped hydro.
- voluntary curtailment of customer load.

TransGrid considered the variables that drive each of the different components of the identified need (ie, the voltage and thermal constraints), what a non-network option would need to be able to provide and has provided an indicative assessment of when such options must be available in the non-network Expression of Interest (EOI) released alongside this PSCR.

[3] The NETI project is being developed by TransGrid Services, a related entity in TransGrid.

This PSCR and the accompanying EOI include the following for both the voltage constraint and the thermal constraint:

- magnitude of voltage support required (MVAr);
- expected cumulative exposure per annum (hours);
- frequency per annum; and
- expected duration per event (hours).

The EOI also specifies the type and form of information we are seeking from proponents in order to have their solutions assessed in the PADR.

TransGrid encourages parties to make contact (via written submissions or otherwise) regarding the potential of non-network options to satisfy, or contribute to satisfying, the identified need for this RIT-T.

Submissions and next steps

The purpose of this PSCR is to set out the reasons we propose 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.

TransGrid welcomes written submissions on the material contained in this PSCR. Submissions are particularly sought on the credible options presented and from potential proponents of non-network options that could meet the technical requirements set out in this PSCR. Submissions are due on 15 July 2021.

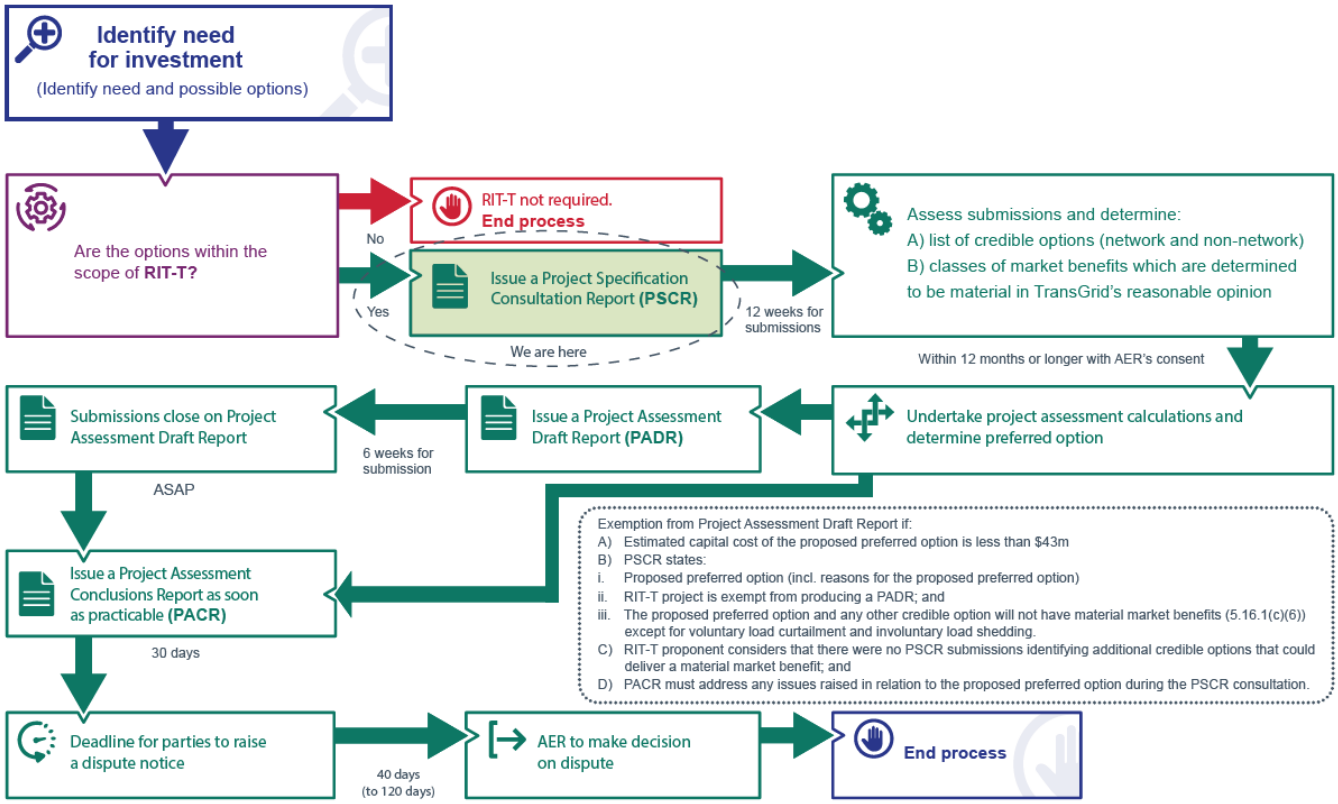
Submissions should be emailed to our Regulation team via regulatory.consultation@transgrid.com.au.[4] In the subject field, please reference 'PSCR Maintaining reliable supply to North West Slopes area.'

At the conclusion of the consultation process, all submissions received will be published on 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 later in 2021.

[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.

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



[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 options for maintaining reliable supply to the North West Slopes area of northern New South Wales (NSW), which is an area covering loads from Tamworth to Moree. Publication of this Project Specification Consultation Report (PSCR) represents the first step in the RIT-T process.

The latest demand forecasts for the North West Slopes indicate that electricity demand is expected to increase substantially in the area going forward. This is driven by a number of substantial industrial loads anticipated to connect, as well as underlying general load growth in Narrabri and Gunnedah.

TransGrid's power system studies forecast that the expected load growth will reach voltage stability and thermal limits on the 132 kV supply network in the North West Slopes area if action is not taken by 2024.

Schedule 5.1.4 of the NER requires TransGrid to plan and design equipment for voltage control to maintain voltage levels within 10 per cent of normal voltage.[6] The NER also requires the power system to be operated in a satisfactory operating state, which requires voltages to be maintained within these levels, both in normal operation and following any credible contingency event.[7]

TransGrid undertook planning studies that show that the current North West Slopes network will not be capable of supplying the combined increases in load in the area without breaching the NER requirements and that voltage-limited constraints will have to be applied in the 132 kV supply network if action is not taken.

Moreover, in addition to the voltage constraints identified, TransGrid's planning studies show that the increased demand will also lead to thermal constraints going forward, particularly during times of low renewable generation dispatch in the region.

This RIT-T therefore examines various network and non-network options for relieving these constraints going forward to ensure compliance with the requirements of the NER and provide the greatest net benefit to the market.

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 would address the identified need;
- outline the technical characteristics that non-network options would need to provide;
- summarise how TransGrid intends to assess options for addressing the identified need in the Project Assessment Draft Report (PADR); and
- allow interested parties to make submissions and provide input to the RIT-T assessment.

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

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6 These levels are specified in Clause S5.1a.4.

7 These requirements are set out in Clauses 4.2.6, 4.2.4 and 4.2.2(b) of the NER. The requirement for secure operation of the power system in Clause 4.2.4 requires the power system to be in a satisfactory operating state following any credible contingency event, that is, to maintain voltage within 10 per cent of normal voltage following the first credible contingency event.

2. The identified need

2.1 Background

The North West Slopes area covers loads from Tamworth to Moree. The area is primarily supplied by 132 kV lines from the Tamworth 330/132 kV substation:

> Line 968 – Tamworth to Narrabri; and

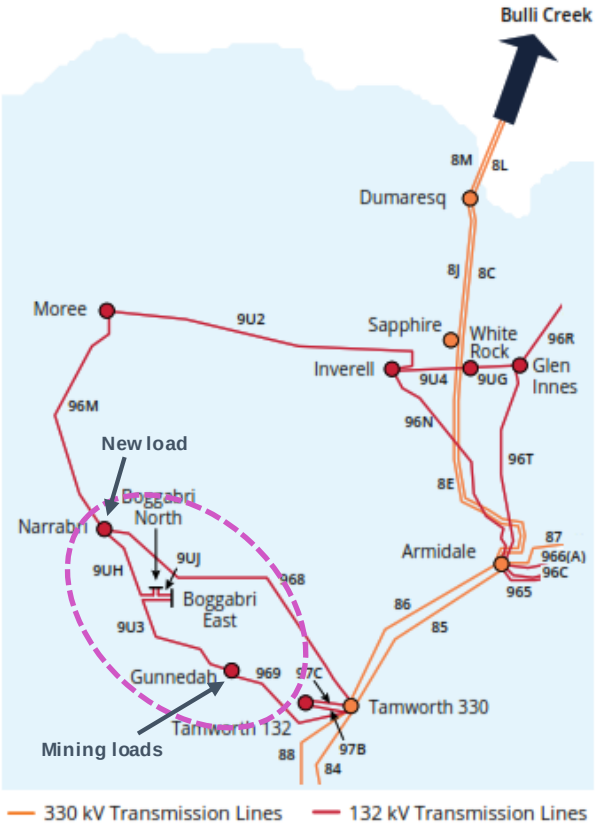
> Line 969 – Tamworth to Gunnedah.

This part of the network is parallel to the 330 kV main system that interconnects the NSW and Queensland systems. Power flows on lines 968 and 969 are therefore affected by power flows on the NSW/Queensland interconnectors QNI and Directlink. At times of heavy power flows between the two states, the power flows on lines 968 and 969 can be significantly impacted by these main system flows.

The Narrabri and Gunnedah 132/66 kV substations supply Essential Energy loads in the area, with each substation having two 60 MVA 132/66 kV transformers. The Boggabri Coal and Maules Creek mines are also connected to the TransGrid 132 kV network via the Boggabri East and Boggabri North switching stations.

The current northern NSW electricity transmission network is shown in in Figure 2-1 below with the area relevant for this RIT-T (the North West Slopes area) circled. The indicative location of the key forecast electricity loads that are discussed in this PSCR (and are publicly announced) are also shown.

Figure 2-1: Northern NSW transmission network



Electricity demand in the North West Slopes is forecast to increase significantly over the next ten years, primarily due to planned connections of new mining and industrial loads in the area. These loads are described in more detail in section 2.3 below.

2.2 Description of the 'identified need'

Schedule 5.1.4 of the NER requires TransGrid to plan and design equipment for voltage control to maintain voltage levels within 10 per cent of normal voltage.[8] The NER also requires the power system to be operated in a satisfactory operating state, which requires voltages to be maintained within these levels, both in normal operation and following any credible contingency event.[9]

TransGrid undertook planning studies that show that the current North West Slopes network will not be capable of supplying the combined increases in load in the area without breaching the NER requirements and that voltage-limited constraints will have to be applied in the 132 kV supply network if action is not taken.

Moreover, in addition to the voltage constraints identified, TransGrid's planning studies show that the increased demand will also lead to thermal constraints, particularly during times of low renewable generation dispatch in the region.

If the longer-term constraints associated with the load growth are unresolved, it could result in the interruption of a significant amount of electricity supply under both normal and contingency conditions due to voltage and thermal limitations in the area.

TransGrid has therefore commenced this RIT-T to assess options to ensure the above NER requirements continue to be met in the North West Slopes area with forecast demand increases.

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, i.e., Schedule 5.1.4 of the NER.

2.3 Assumptions underpinning the identified need

This section describes the assumptions underpinning TransGrid's assessment of the identified need. As part of the planning studies undertaken to identify the voltage-limited constraints and thermal limits if no action is taken, assumptions were made regarding:

- load forecasts for new mining loads in the area;
- general system demand in the North West Slopes network; and
- renewable generation in the region (and, in particular, solar and wind generation).

The forecast voltage and thermal constraints are sensitive to these three sets of underlying assumptions.

2.3.1 Electricity demand from expected new mining loads

Essential Energy has advised that Whitehaven Coal Limited's Vickery Coal Mine (VCM) is not included in the base demand forecast. However, the VCM was approved by the Independent Planning Commission of NSW in August 2020 and is expected to be connecting to the distribution network. The project is located in the Gunnedah Coalfield, which is approximately 25 km north of Gunnedah.[10]

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[8] These levels are specified in Clause S5.1a.4.

[9] These requirements are set out in Clauses 4.2.6, 4.2.4 and 4.2.2(b) of the NER. The requirement for secure operation of the power system in Clause 4.2.4 requires the power system to be in a satisfactory operating state following any credible contingency event, that is, to maintain voltage within 10 per cent of normal voltage following the first credible contingency event.

[10] Australian Mining Monthly, *Vickery extension on track for 2021 construction completion,* 8 June 2019, available at: https://www.miningmonthly.com/development/international-coal-news/1364804/vickery-extension-on-track-for-2021-construction-completion; and Whitehaven Coal, *Vickery Extension Project Environmental Impact Statement | Introduction*, p 1-1, available at: https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSD-7480%2120190303T213410.742%20GMT.

The scope of the VCM project includes the construction of a new 66 kV/11 kV substation that would be serviced by an existing 66 kV overhead power line.[11] In light of the project's location, it will likely be supplied by TransGrid's Gunnedah 132/66kV substation. This new additional load is expected to require supply from 2021, with maximum electricity demand when fully operational of approximately 62,700 MWh per annum.[12]

Essential Energy has also advised that Santos NSW (Eastern) Pty Ltd is proposing to develop the Narrabri Gas Project. The project canvasses connecting to the NSW power grid by drawing power from the existing Wilga Park Power Station via a new power distribution line.[13] As a result, it would be supplied from TransGrid's Narrabri 132/66 kV substation. This is not included in Essential Energy's base demand forecast. The specific load forecasts for this project have not been included in this PSCR due to confidentiality reasons.

The Narrabri Gas Project has received development consent from the Federal Government,[14] contingent on a number of environmental conditions being met. Santos has announced that this approval will allow them to begin an appraisal program ahead of a Final Investment Decision (FID) for the next phase of project development.[15] The FID date is currently scheduled for first half 2023 and, once approved, stage 1 of production will require supply from 2025.[16]

The development of a pipeline that links the Narrabri project to the existing Moomba to Sydney Pipeline is being investigated by APA group.[17] The proposed route would commence to the north of the Pilliga National Park and Pilliga West State Conservation Areas, before extending west-southwest to connect to the Moomba to Sydney Pipeline at the Bundure mainline valve station, approximately 100 km west of Condobolin. Should this gas pipeline not be installed, it may affect the ability to fully develop the Narrabri Gas Project (which in-turn has implications for the certainty of the electricity demand projections).

There is a further mining load that has expressed interest to TransGrid in connecting in the area. However, specific load information for this potential mine has not been presented in this PSCR due to it being commercially sensitive and not yet public.

Since these loads are not yet committed, but are expected to have a direct impact on the likely preferred option under this scenario, TransGrid has constructed three load forecasts proposed to be used for the PADR assessment:

- a low demand forecast:
  - assumes that VCM and the Narrabri Gas Project both connect to the network;
  - however, as the development of the gas pipeline linking the Narrabri Gas Project to the existing Moomba to Sydney Pipeline could affect the latter stages of the Narrabri Gas Project, only the first stage is assumed to connected to the network under this scenario;
- a central forecast:
  - assumes that both VCM and the Narrabri Gas Project connect to the network;
  - assumes the full forecast for the Narrabri Gas Project;
- a high forecast;

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11 Whitehaven Coal, *Vickery Extension Project Environmental Impact Statement | Project description*, p 2-18, available at: https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSD-7480%2120190303T213412.005%20GMT

12 Whitehaven Coal, *Vickery Extension Project Environmental Impact Statement | Project description*, p 2-31, available at: https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSD-7480%2120190303T213412.005%20GMT

13 Santos, *Narrabri Gas Project Environmental Impact Statement | Project description,* p 6-18, available at: https://majorprojects.accelo.com/public/1e6475194c440a225a59dddcb004fd53/Chapter%2006%20Project%20description.pdf

14 NSW planning portal website, https://www.planningportal.nsw.gov.au/major-projects/project/10716, accessed on 25 November 2020

15 Santos' Narrabri Gas Project website, https://narrabrigasproject.com.au/2020/11/santos-welcomes-federal-signoff-on-narrabri-gas-project/, accessed on 25 November 2020

16 Santos 2020 Investor Day 1 Dec 2020, available as "Santos upgrades 2020 guidance" at: https://www2.asx.com.au/markets/company/STO

17 APA group website project updates, https://www.apa.com.au/about-apa/our-projects/western-slopes-pipeline/project-updates/, accessed on 22 December 2020

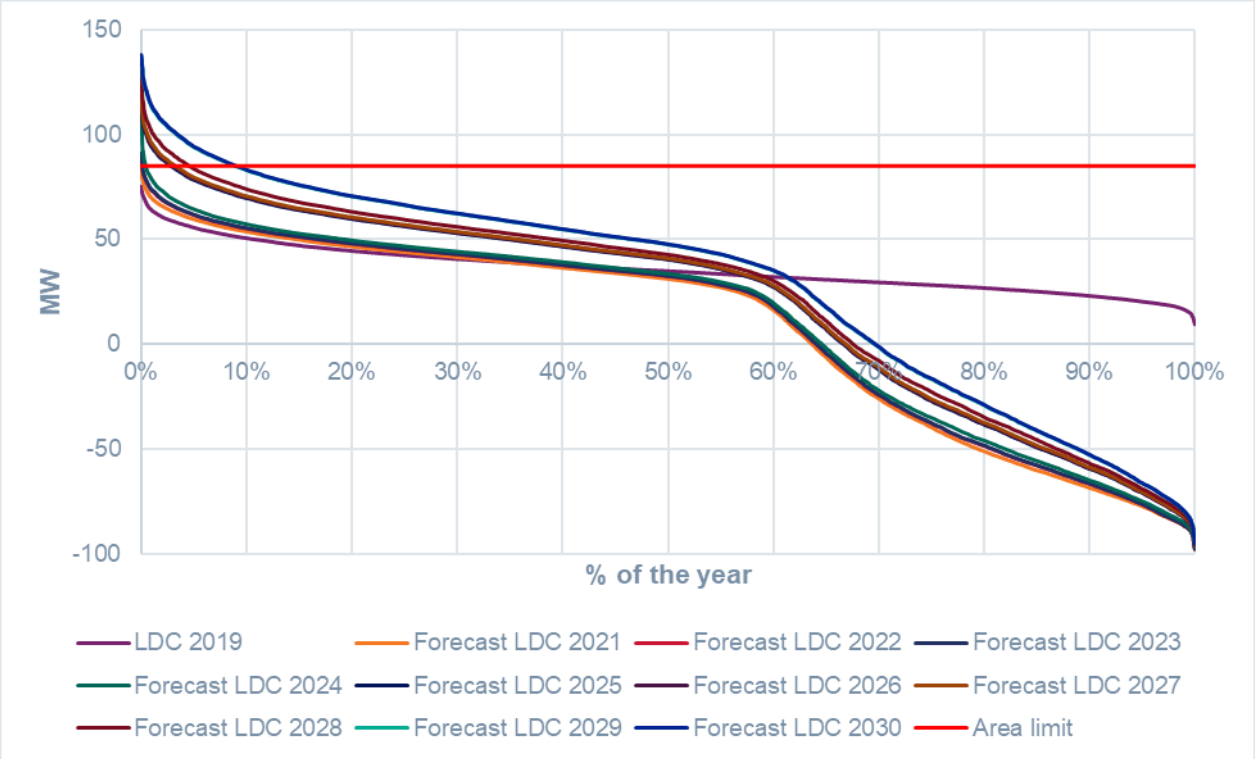
– assumes that along with VCM and the Narrabri Gas Project, the additional confidential mine connects.

2.3.2 General system demand in the North West Slopes area

TransGrid has forecast there to be steady load increases for the North West Slopes area over the next twenty years, with Narrabri having the greatest expected load increase.

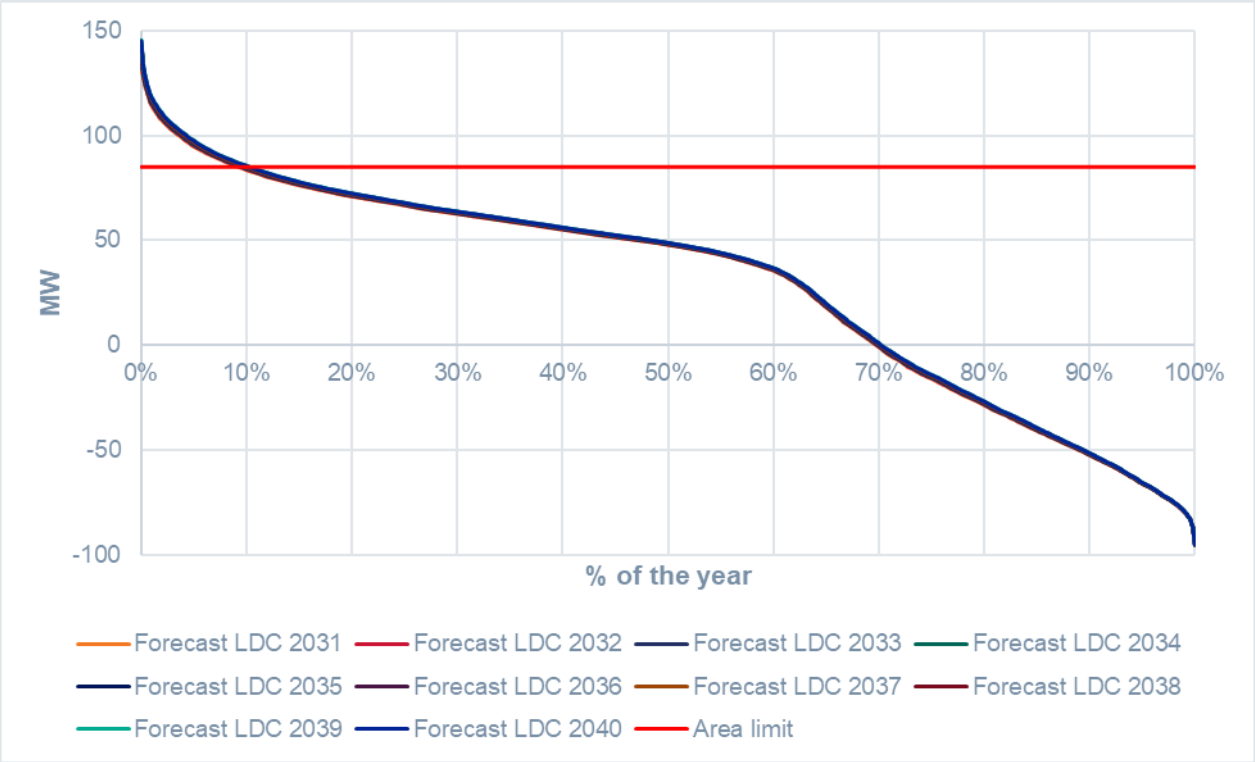
The two figures below present the actual 2019, as well as the forecast future, load duration curves (LDCs) and demand limits for the Narrabri and Gunnedah 66 kV Bulk Supply Points (BSP) along with the existing and forecast mining loads under the central scenario. The LDCs represent the net demand (i.e., total demand minus committed embedded renewable generation in the area) and show the significant expected increase in demand going forward (to 2029, maintained around that level to beyond 2040) under the central scenario, as well as how the voltage limits are expected to be exceeded an increasing percentage of the year if action is not taken. This data provides a visual representation of the load that could be at risk during a calendar year under the central scenario if action is not taken.[18]

Figure 2-2: Forecast LDCs and demand limits for the North West Slopes area, actual 2019 and forecast to 2030 under the central scenario



[18] The data shown in these LDCs is the aggregate of the load at Narrabri 66 kV, Boggabri North 132 kV, Boggabri East 132 kV and Gunnedah 66 kV, less the Gunnedah Solar Farm generation.

Figure 2-3: Forecast LDCs and demand limits for the North West Slopes area, forecast 2031 to 2040 under the central scenario



2.3.3 Renewable generation in the region

In addition to the longer-term voltage constraints, the forecast increased demand going forward is expected to also lead to thermal constraints, particularly at times of low renewable generation dispatch in the region.

There are a number of in-service and planned renewable generator connections in the northern NSW region. Table 2-1 summarises these systems.

Table 2-1: Current and planned renewable generation in the northern NSW region

Generating System	Connection location	Capacity (MW)	Status
Moree Solar Farm	Essential Energy's 66 kV Moree network	56	In-service
White Rock Wind and Solar Farm	White Rock substation	172.5	In-service
Gunnedah Solar Farm	9U3 Gunnedah to Boggabri East 132 kV line (close to Gunnedah)	110	Committed (expected commissioning in Q4 2021)
Tamworth Solar Farm	969 Tamworth to Gunnedah 132 kV line	65	Advanced*

**'Advanced' connection is in the connection application process with the connecting NSP.*

TransGrid notes that there are also other new potential renewable energy generation projects proposed in the area that are not yet at a committed or advanced stage.

Additional renewable generation could assist with addressing/minimising the identified need as it can provide reactive support while generating active power subject to its voltage control strategy. TransGrid took into account in-service and committed renewable generation in assessing the identified need for this RIT-T.

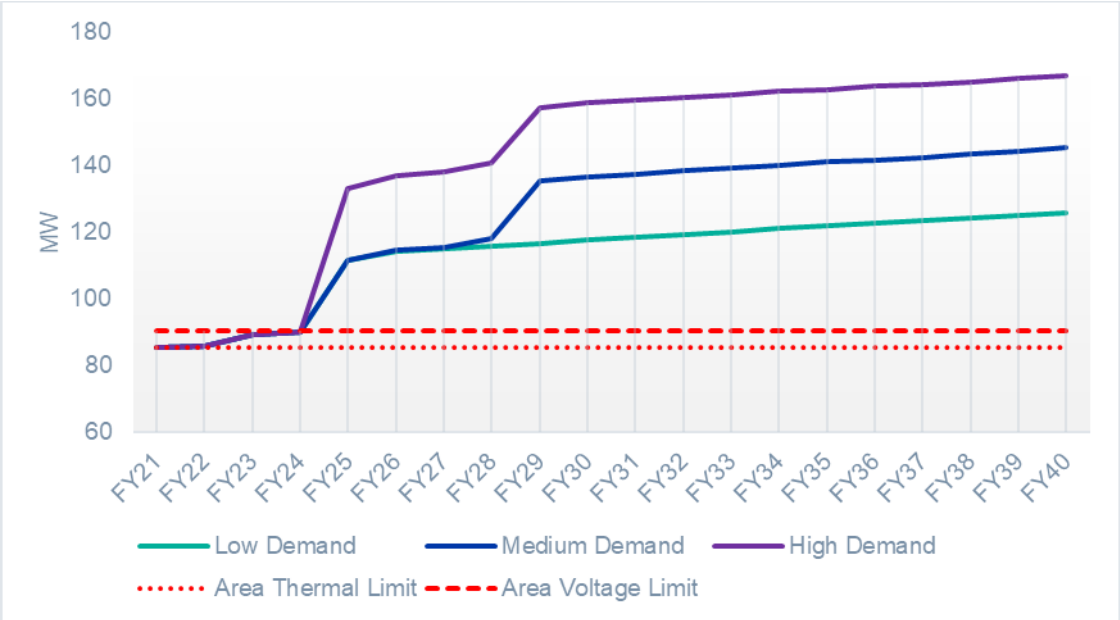
2.3.4 Forecast voltage and thermal limits if action is not taken

TransGrid's system studies show that the available capacity in the North West Slopes area is limited following connection of the Narrabri Gas Project by:

> thermal constraints on line 969 under system normal conditions; and
> voltage stability constraints between Gunnedah and Narrabri for a contingent outage of line 969 or 968.

Figure 2-4 shows the voltage limits for the North West Slopes area considering the maximum demand that can be supplied without resulting in network voltages below 0.9 pu, under system normal and under (N-1) contingency conditions, along with the thermal limit due to the increased demand. These voltage and thermal supply limits are shown against the backdrop of the expected future load in the area under the three different demand scenarios TransGrid proposes to investigate in the PADR.

Figure 2-4: Peak demand forecast with voltage and thermal limits for the North West Slopes area



The thermal constraint on line 969 due to the inclusion of stage 1 of the Narrabri Gas Project in 2025 can occur during system normal conditions or a contingent outage of line 968 under the low and central scenarios when there is no generation in service in the area to offset the load. It can also occur during system normal conditions from 2029 onwards under the central scenario following the inclusion of stage 2 of the Narrabri Gas Project, even with some generation in service.

The voltage stability constraint occurs for a trip of line 969, and is expected by 2025 in all demand scenarios.

The thermal constraint is expected to occur from the inclusion of VCM earlier in the forecast period (as can be seen in Figure 2-4 under the high demand scenario) but can also be temporarily managed by operational measures until stage 1 of the Narrabri Gas Project comes online.

Under the high scenario, the constraints are worsened from 2025 for a trip of line 969, which becomes significantly worse due to the demand in the area being mostly fed from the one long transmission line (i.e., the 132 kV line 968, which is 170 km in length). The options outlined in section 3, therefore involve larger levels of augmentation to the network in 2025 to facilitate the demand under the high scenario (e.g., duplication of line 968) as well as larger levels of dynamic reactive support.

Under the central and high scenarios, the voltage constraints are expected to worsen in 2028 and 2029. Under these scenarios, voltages at Narrabri and Gunnedah would be outside of the planning criteria set out in Schedule 5.1.4 of the NER for an outage of one of the 132 kV transmission lines supplying Narrabri and Gunnedah from Tamworth (lines 968 or 969).

Voltages in the area will drop to unsustainable levels and voltage collapse could occur in the region following a contingency on line 969 due to insufficient dynamic reactive support in the region under all scenarios. This voltage collapse could lead to significant amounts of load being shed throughout the North West Slopes area.

Under all scenarios outlined in this PSCR, the load increase at the Narrabri substation leads to the firm supply capacity for the transformers at this location being exceeded.

3. Options that meet the identified need

TransGrid considers credible options in this RIT-T assessment as those that would meet the identified need from a technical, commercial, and project delivery perspective.[19] This will include any credible options that are put forward by proponents in response to this PSCR.

TransGrid considers that each of the credible network options outlined in this PSCR requires the installation of a third 60 MVA 132/66 kV transformer at Narrabri due to the firm supply capacity of the existing transformers at this location being exceeded under all scenarios. This new transformer is estimated to cost between $15 million and $25 million and is assumed to be installed by 2024/25 for all options and scenarios.

Aside from the new 132/66 kV transformer at Narrabri, the credible network options differ in the near-term by where, how and when new capacity is added to the North West Slopes region. In particular, TransGrid currently considers there to be four broad types of credible option, which, outside of the common new transformer at Narrabri, centre on:

- uprating the existing line 969 from Tamworth to Gunnedah;
- installing new single or double circuit transmission lines between Tamworth and Gunnedah;
- rebuilding the existing line 969 from Tamworth to Gunnedah to be a double circuit line; and
- connecting to a potential new private transmission project in the Gunnedah area called the New England Transmission Infrastructure (NETI).[20]

Most credible options include the provision of dynamic reactive support at Narrabri which may be provided by a SVC, STATCOM, synchronous condenser or grid-scale battery. One option considers a new transmission line between Gunnedah and Narrabri as an alternative to dynamic reactive support.

In addition, TransGrid considers that non-network solutions may be able to form credible options for this RIT-T, either as standalone options or in combination with network options (or components of these options). Section 4 and the accompanying EOI provide details on the technical information that proponents of non-network options need to provide in order to enable their option to be considered in this RIT-T.

Table 3-1 summarises each of the credible options TransGrid currently considers can meet the identified need.

[19] As per clause 5.15.2(a) of the NER.

[20] The NETI project is being developed by TransGrid Services, a related entity in TransGrid.

Table 3-1: Summary of the credible options

Option	Description	Estimated capex per component ($2020/21)	Total expected capex ($2020/21)	Expected timing (central load forecasts)
Option 1 – Uprating the existing line 969 from Tamworth to Gunnedah				
1A	Install a third 60 MVA 132/66 kV transformer at Narrabri	$20-30 million	$240-370 million	2024/25
	Upgrade the existing 969 line between Tamworth 330/132 kV and Gunnedah 132/66 kV substations to a rating of 157 MVA	$25-40 million		
	Install a 132 kV +50 MVAr (capacitive) -20 MVAr (inductive) SVC or STATCOM or SYNCON at Gunnedah Substation	$60-90 million		
	Upgrade the 9UH line between Narrabri and Boggabri East to a rating of 100 MVA	$50-75 million		
	Upgrade the existing 968 line between Tamworth 330 and Narrabri substations to a rating of at least 160 MVA	$85-135 million		
	Install a 132 kV +60 MVAr -20 MVAr SVC or STATCOM or SYNCON at Narrabri	$60-90 million	$60-90 million	2028/29
1B	Install a third 60 MVA 132/66 kV transformer at Narrabri	$20-30 million	$155-235 million	2024/25
	Upgrade the existing 969 line to a rating of 157 MVA	$25-40 million		
	Install a 132 kV +50 MVAr (capacitive) -20 MVAr (inductive) SVC or STATCOM or SYNCON at Gunnedah Substation	$60-90 million		
	Upgrade the 9UH line to a rating of 100 MVA	$50-75 million		
	Build a new 132 kV line between Tamworth 330/132 kV and Narrabri 132/66 kV substations	$130-220 million	$130-220 million	2028/29

Option	Description	Estimated capex per component ($2020/21)	Total expected capex ($2020/21)	Expected timing (central load forecasts)
Option 2 – New single or double circuit transmission lines between Tamworth and Gunnedah				
2A	Install a third 60 MVA 132/66 kV transformer at Narrabri	$20-30 million	$165-265 million	2024/25
	Upgrade the existing 969 line to a rating of 135 MVA	$25-40 million		
	Upgrade the 9UH line to a rating of 100 MVA	$50-75 million		
	Build a new single circuit 160 MVA 132 kV line between Tamworth 330 and Gunnedah.	$70-120 million		
	Install a 132 kV +50 MVAr -20 MVAr SVC or STATCOM or SYNCON at Narrabri.	$60-90 million	$60-90 million	2028/29
2B	Install a third 60 MVA 132/66 kV transformer at Narrabri	$20-30 million	$170-260 million	2024/25
	Build a new double circuit 132 kV line between Tamworth 330 and Gunnedah, each circuit rated at 160 MVA	$90-140 million		
	Upgrade the 9UH line to a rating of 100 MVA	$50-75 million		
	Decommission the existing 969 transmission line	$10-15 million		
	Installation of a 132 kV +50 MVAr -20 MVAr SVC or STATCOM or SYNCON at Narrabri.	$60-90 million	$60-90 million	2028/29
2C	Install a third 60 MVA 132/66 kV transformer at Narrabri	$20-30 million	$105-180 million	2024/25
	Upgrade the existing 969 line to a rating of 135 MVA	$25-40 million		
	Build a new single circuit 160 MVA 132 kV line between Tamworth 330 and Gunnedah	$60-110 million		
	Build a new single circuit 132 kV line between Narrabri and Gunnedah	$90-150 million	$90-150 million	2028/29
2D	Install a third 60 MVA 132/66 kV transformer at Narrabri	$20-30 million	$315-485 million	2024/25
	Upgrade the existing 969 line to a rating of 135 MVA	$25-40 million		
	Upgrade the 9UH line to a rating of 100 MVA	$50-75 million		
	Build a new single circuit 330 kV line between Tamworth 330 and Gunnedah operated at 132 kV, rated at least 160 MVA	$220-340 million		

Option	Description	Estimated capex per component ($2020/21)	Total expected capex ($2020/21)	Expected timing (central load forecasts)
	Install a 132 kV +50 MVAr -20 MVAr SVC or STATCOM or SYNCON at Narrabri	$60-90 million	$60-90 million	2028/29
	Option 3 – Rebuilding the existing line 969 from Tamworth to Gunnedah to be a double circuit line			
3A	Install a third 60 MVA 132/66 kV transformer at Narrabri 132/66 kV Substation Rebuild the existing 969 line between Tamworth 330 and Gunnedah Substations as a double circuit, each circuit rated at 157 MVA Upgrade the 9UH line between Narrabri and Boggabri East to a rating of 100 MVA	$20-30 million $70-110 million $50-75 million	$140-215 million	2024/25
	Install a 132 kV +60 MVAr (capacitive) - 20 MVAr (inductive) SVC or STATCOM or SYNCON at Narrabri Substation	$60-90 million	$60-90 million	2028/29
3B	Install a third 60 MVA 132/66 kV transformer at Narrabri 132/66 kV Substation Rebuild the existing 969 line between Tamworth 330 and Gunnedah Substations as a double circuit Upgrade the 9UH line between Narrabri and Boggabri East to a rating of 100 MVA	$20-30 million $70-110 million $50-75 million	$140-215 million	2024/25
	Install a 50 MW (50 MWh) BESS at Narrabri 132 kV	$90-150 million	$90-150 million	2028/29
3C	Install a third 60 MVA 132/66 kV transformer at Narrabri 132/66 kV Substation Rebuild the existing 969 line between Tamworth 330 and Gunnedah Substations as a double circuit	$20-30 million $70-110 million	$90-140 million	2024/25
	Build a new 132 kV line between Narrabri and Gunnedah rated at approximately 160 MVA	$90-150 million	$90-150 million	2028/29

Option	Description	Estimated capex per component ($2020/21)	Total expected capex ($2020/21)	Expected timing (central load forecasts)
Option 4 – Connection to the New England Transmission Infrastructure (NETI) project				
4	Install a third 60 MVA 132/66 kV transformer at Narrabri	$20-30 million	$180-280 million	2024/25
	Build a new 330/132 kV transformer at the NETI substation site	$25-40 million		
	Build a new single circuit 160 MVA 132 kV line between Gunnedah and the new NETI substation	$40-65 million		
	Install a new 132 kV phase shifting transformer at Gunnedah Substation	$20-30 million		
	Upgrade the existing 969 line to a rating of 135 MVA	$25-40 million		
	Upgrade the 9UH line to a rating of 100 MVA	$50-75 million		
	Install a 132 kV +50 MVAr -20 MVAr SVC or STATCOM or SYNCON at Narrabri	$60-90 million	$60-90 million	2028/29

Option	Description	Estimated capex ($2020/21)	Expected timing (central load forecasts)
Option 5 – Non-network options			
5	The assessment of non-network options will depend on responses received to this PSCR. However, at this stage, TransGrid considers these technologies may include, but are not limited to, the following: > generation (both embedded and grid-connected); and > energy storage (bulk or aggregated systems, but are not limited to): – sealed batteries; – flow batteries; – concentrated solar thermal with storage; – compressed air storage; and – pumped hydro. > voluntary curtailment of customer load. Section 4 and the accompanying EOI provide details on the technical information that proponents of non-network options need to provide in order to enable their option to be considered in this RIT-T.	To be estimated based on responses to the EOI.	To be estimated based on responses to the EOI.

While indicative cost estimates for the credible options have been provided, more accurate figures are expected to be used for the cost-benefit analysis in the PADR. In addition, while TransGrid currently expects that annual operating costs can be approximated as two per cent of the total capex, this will be reviewed further as part of the PADR and more specific estimates may be developed.

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

3.1 Base case

Consistent with the RIT-T requirements, the assessment undertaken in the PADR will 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:[21]

> *"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"*

Under the base case, where the longer-term constraints associated with load growth in the North West Slopes area are unresolved, there is expected to be significant interruption of supply to loads in the area under

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

normal and contingency conditions due to voltage/thermal limitations and/or voltage collapse in the local supply network.

While this is not a situation TransGrid plans to encounter, and this RIT-T has been initiated specifically to avoid it, the assessment is required under the RIT-T to use this base case as a common point of reference when estimating the net benefits of each credible option.

At this stage, TransGrid is not intending to quantify the full extent of the expected involuntary load shedding under the base case as part of the PADR analysis, as each option will address the constraints and avoid largely the same amount of unserved energy, i.e., quantifying the full extent of avoided involuntary load shedding under each option will not assist in identifying the preferred option under the RIT-T. Moreover, the levels of unserved energy under the base case are expected to be extremely high and so will dwarf the other quantified benefits (e.g., TransGrid estimates that these will exceed $850 million by 2025 under the central demand forecasts[22] and increase thereafter). TransGrid is however intending to estimate the *differences* in the expected avoided involuntary shedding *between* options, i.e., to the extent that they are expected to generate different levels of avoided involuntary shedding (such as where one option can be commissioned earlier than another).

TransGrid considers this approach is consistent with the view of Dr. Biggar, Special Economic Adviser to the AER, in his 2017 review of the Powering Sydney's Future RIT-T, where it was noted that the unserved energy under the base case is essentially irrelevant and, in that case, as is the case for this RIT-T, the unserved energy reaches astronomically high levels under the base case. Dr. Biggar suggested it is not correct to allow these costs to increase to arbitrarily high levels and that they should be capped, which allows a more meaningful comparison between options.[23]

3.2 Option 1 – Uprating the existing line 969 from Tamworth to Gunnedah

This option involves uprating the existing line 969 and the two variants test different line augmentations and dynamic reactive support levels at Narrabri and Gunnedah.

Option 1A requires the installation of a third transformer at Narrabri, upgrade of the 968, 969, and 9UH 132 kV lines, and installation of dynamic reactive support at Gunnedah and Narrabri,

Option 1B requires the installation of a third transformer at Narrabri, upgrade of the 969 and 9UH 132 kV lines, installation of dynamic reactive support at Gunnedah, and the building of a new 132 kV line between Narrabri and Tamworth 330.

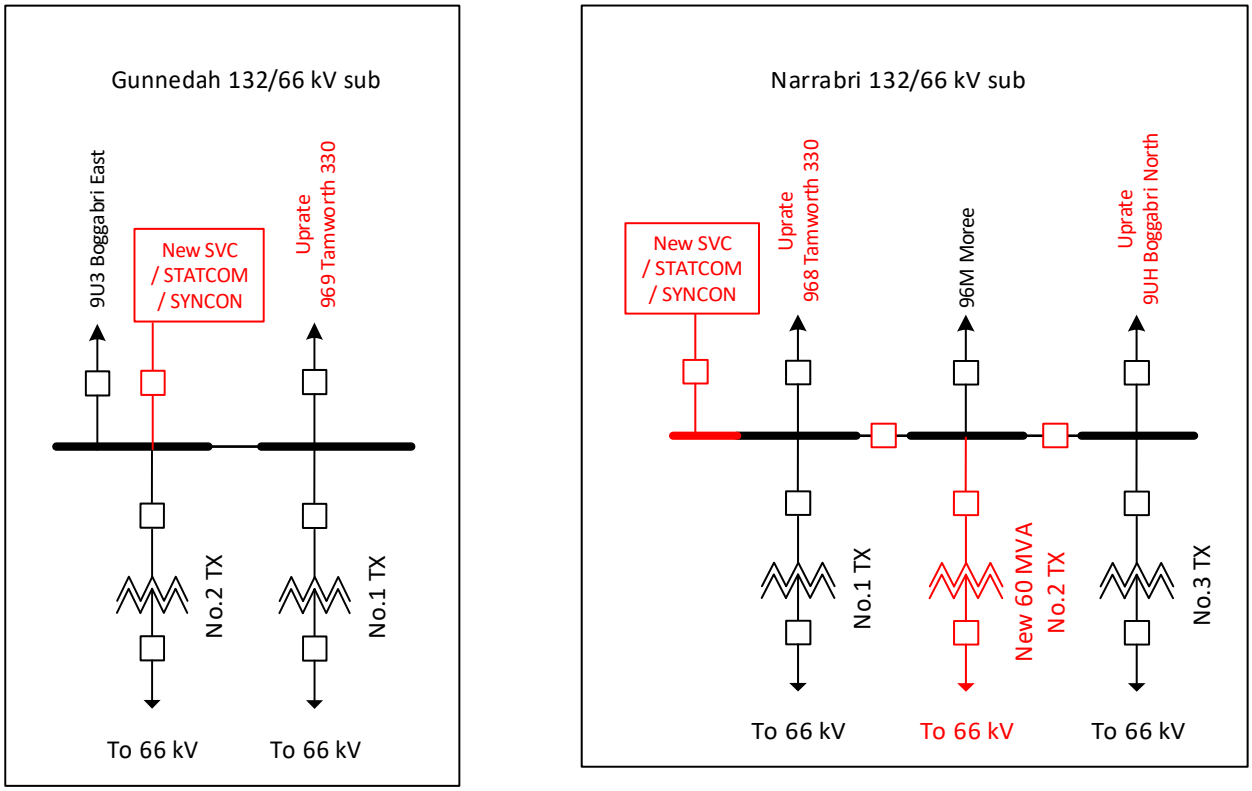
The details of the scope of the various elements for Option 1A and Option 1B is shown in Table 3-1 above.

Indicative network diagrams for Option 1A are shown in Figure 3-1 below (new elements are shown in red).

[22] The value of this unserved energy has currently been estimated using the AER NSW & ACT headline VCR. All unserved energy calculations in the PADR will be updated using a more detailed load-weighted VCR based on the AER estimates and the different load types affected.

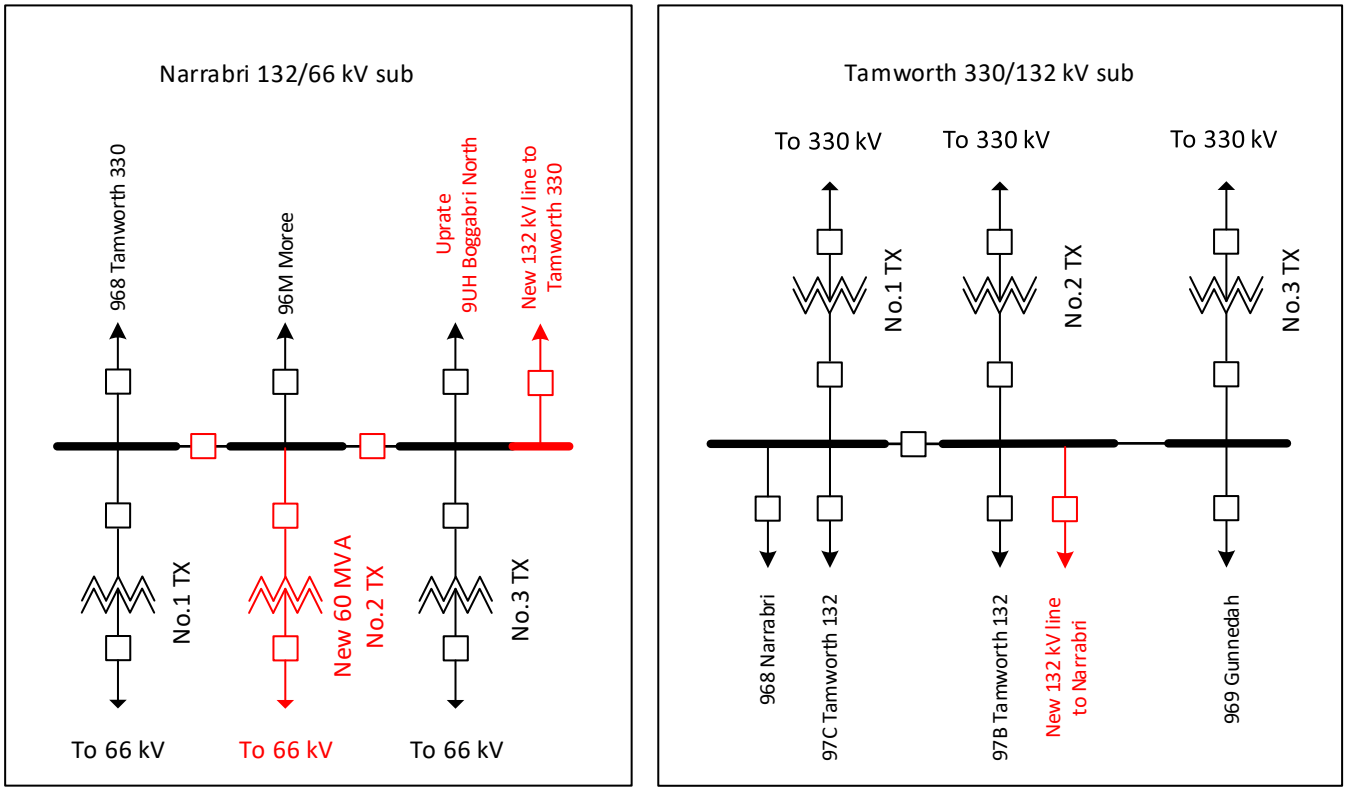
[23] Biggar, D., *An Assessment of the Modelling Conducted by TransGrid and Ausgrid for the 'Powering Sydney's Future' Program*, May 2017, pp. 12-16.

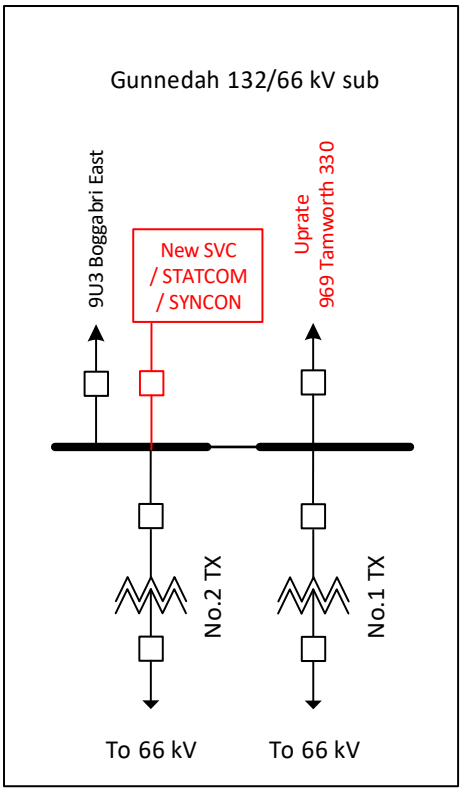
Figure 3-1: Network diagrams for Option 1A



Indicative network diagrams for Option 1B are shown in Figure 3-2 below.

Figure 3-2: Network diagrams for Option 1B




Gunnedah 132/66 kV sub
9U3 Boggabri East
New SVC
/ STATCOM
/ SYNCON
Uprate
969 Tamworth 330
No.2 TX
No.1 TX
To 66 kV
To 66 kV

3.3 Option 2 – New single or double circuit transmission lines between Tamworth and Gunnedah

This option involves installing new single or double circuit transmission lines between the Tamworth 330 kV substation and Gunnedah with the variants testing different line augmentations.

Option 2A requires the installation of a third transformer at Narrabri, upgrade of the 969 and 9UH 132 kV lines, installation of dynamic reactive support at Narrabri, and the building of a new 132 kV line between Gunnedah and Tamworth 330.

Option 2B requires the installation of a third transformer at Narrabri, upgrade of the 9UH 132 kV line, installation of dynamic reactive support at Narrabri, and the building of a new double circuit 132 kV line between Gunnedah and Tamworth 330, while decommissioning the existing 969 line.

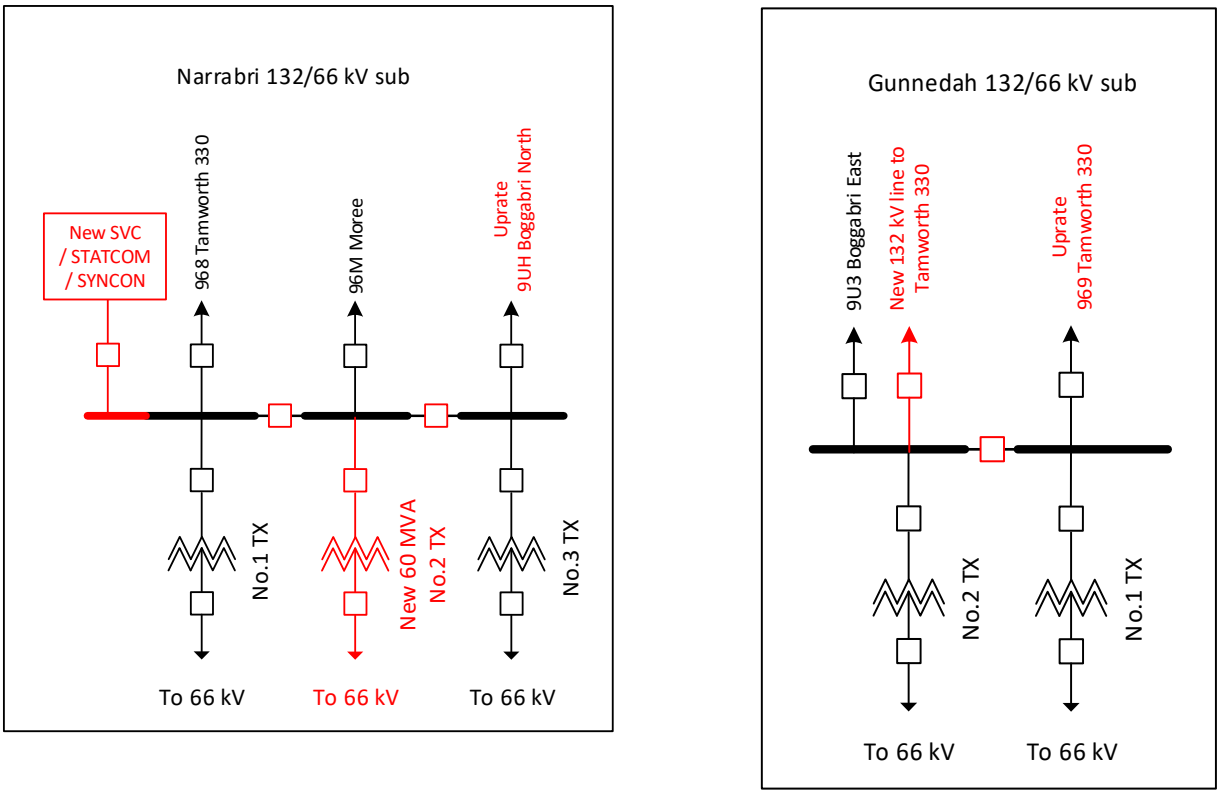
Option 2C requires the installation of a third transformer at Narrabri, upgrade of the existing 969 line, and the building of two new 132 kV lines, one between Tamworth 330 and Gunnedah, and the other between Gunnedah and Narrabri.

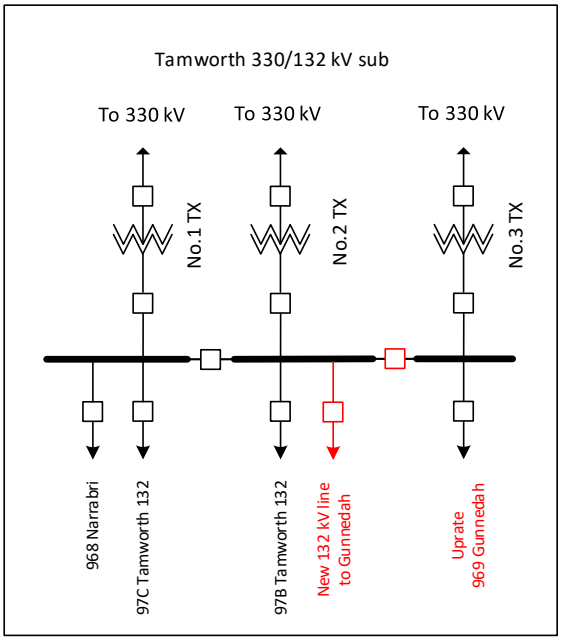
Option 2D requires the installation of a third transformer at Narrabri, upgrade of the 969 and 9UH 132 kV lines, installation of dynamic reactive support at Narrabri, and the building of a new 330 kV line (operated at 132 kV) between Tamworth 330 and Gunnedah.

The details of the scope of elements for Option 2A, Option 2B, Option 2C and Option 2D is shown in Table 3-1 above.

Indicative network diagrams for Option 2A are shown in Figure 3-3 below.

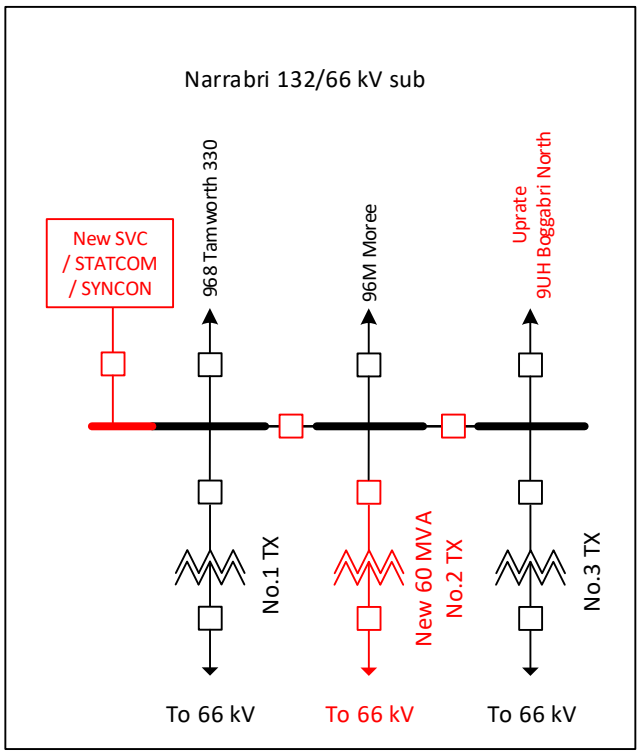
Figure 3-3: Network diagrams for Option 2A

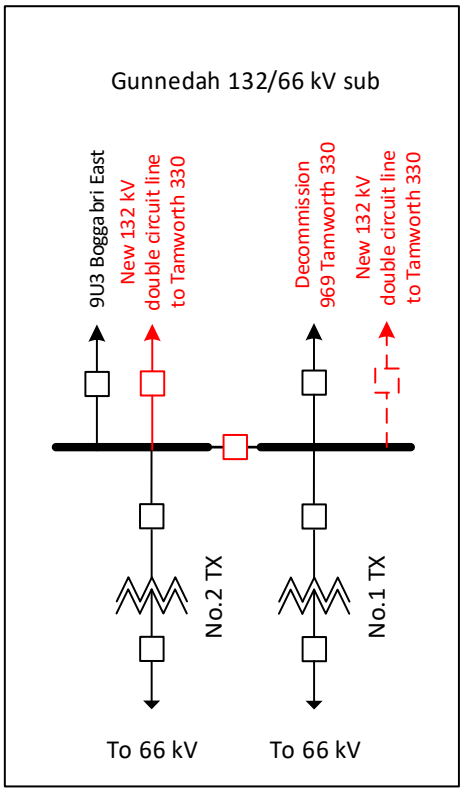


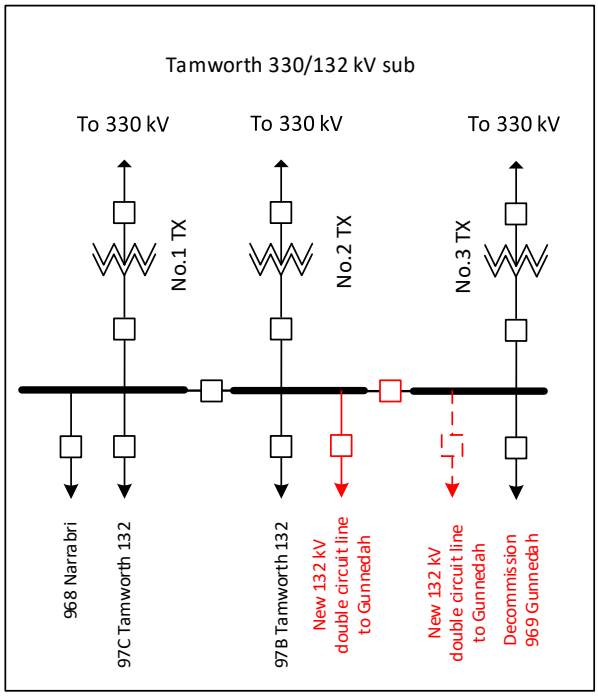


Indicative network diagrams for Option 2B are shown in Figure 3-4 below.

Figure 3-4: Network diagrams for Option 2B

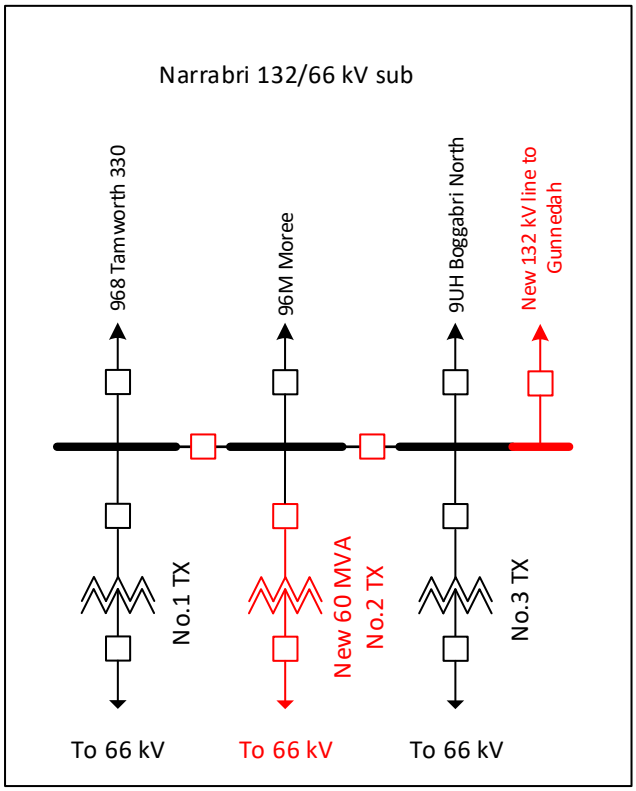


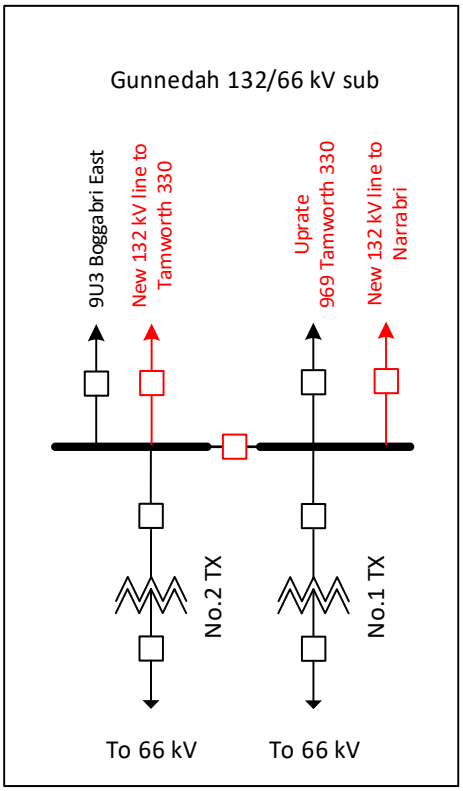


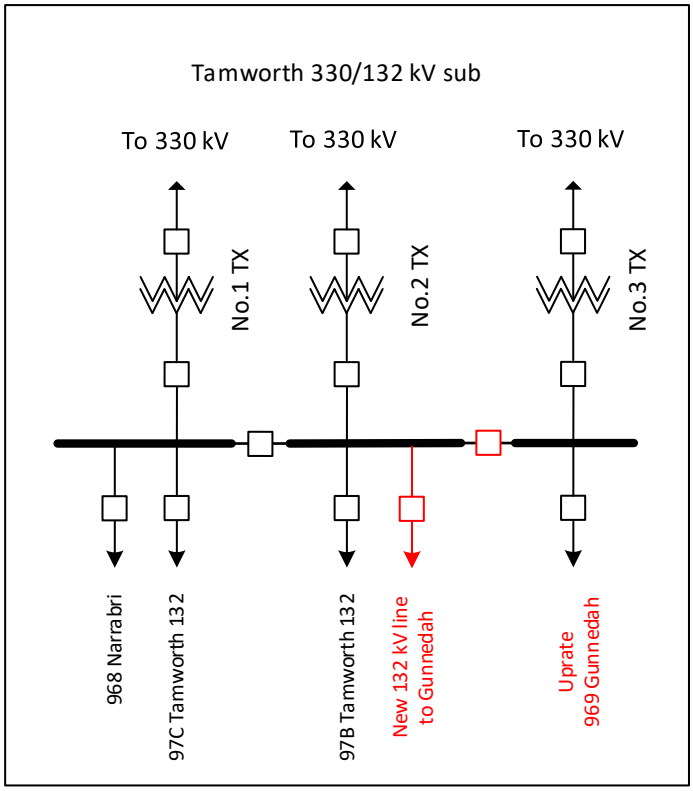


Indicative network diagrams for Option 2C are shown in Figure 3-5 below.

Figure 3-5: Network diagrams for Option 2C

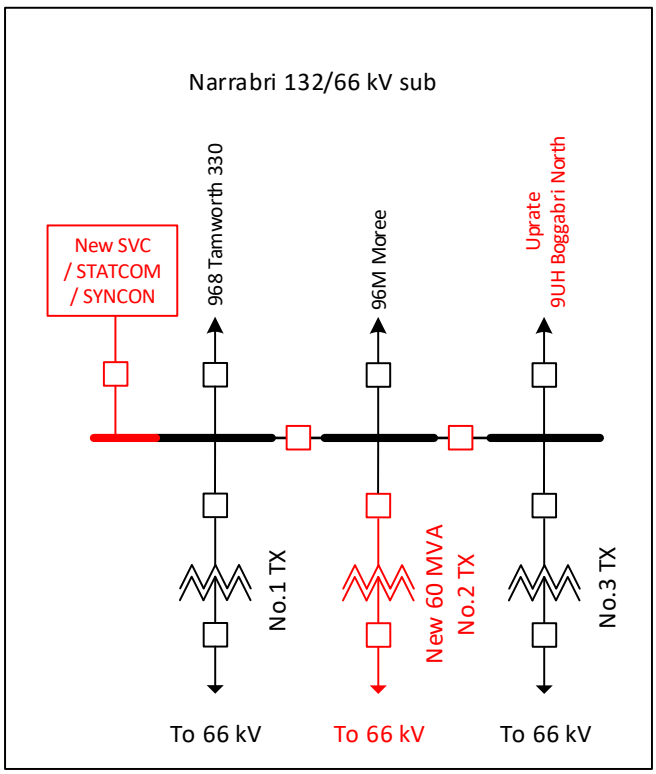


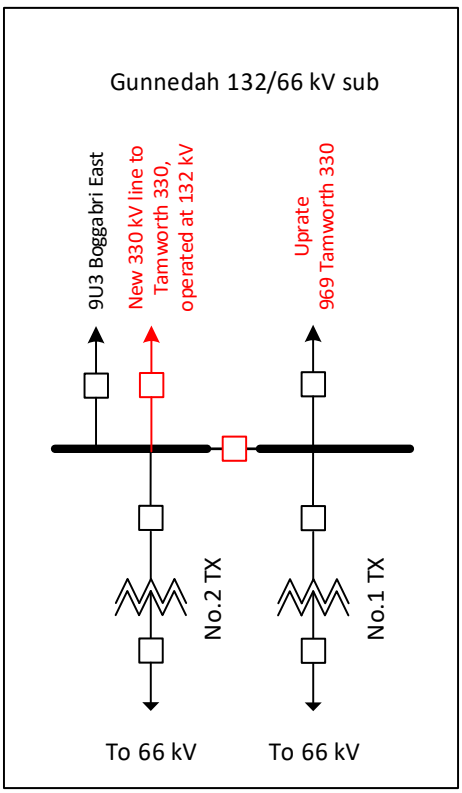


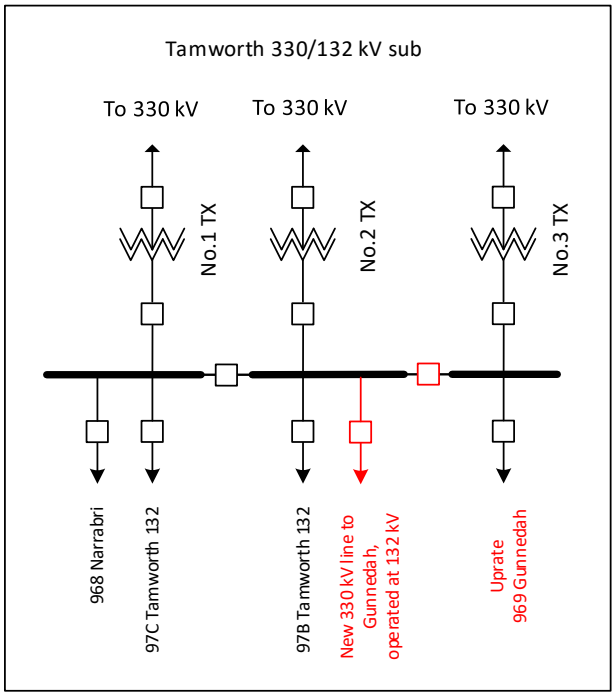


Indicative network diagrams for Option 2D are shown in Figure 3-6 below.

Figure 3-6: Network diagrams for Option 2D







3.4 Option 3 – Rebuilding the existing line 969 from Tamworth to Gunnedah to be a double circuit line

This option involves rebuilding line 969 to be a double circuit line with the three variants testing different line augmentations and dynamic reactive support levels.

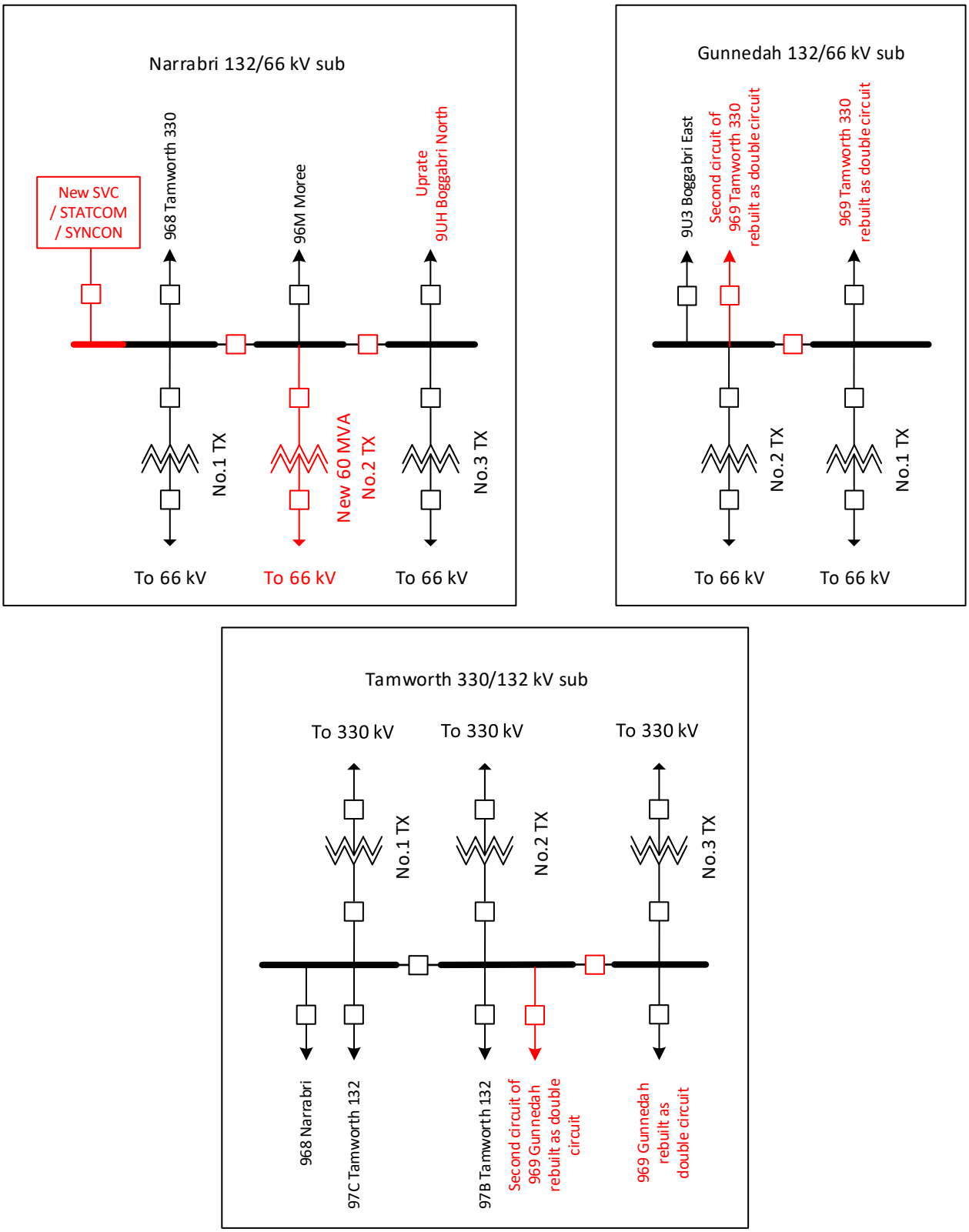
Option 3A requires the installation of a third transformer at Narrabri, upgrade of the 9UH 132 kV line, installation of dynamic reactive support at Narrabri, and the rebuilding of the existing 969 line as a double circuit.

Option 3B requires the installation of a third transformer at Narrabri, upgrade of the 9UH 132 kV line, installation of a battery at Narrabri, and the rebuilding of the existing 969 line as a double circuit.

Option 3C requires the installation of a third transformer at Narrabri, rebuilding of the existing 969 line as a double circuit, and building a new 132 kV line between Narrabri and Gunnedah. The details of the scope of the elements for Option 3A, Option 3B and Option 3C is shown in Table 3-1 above.

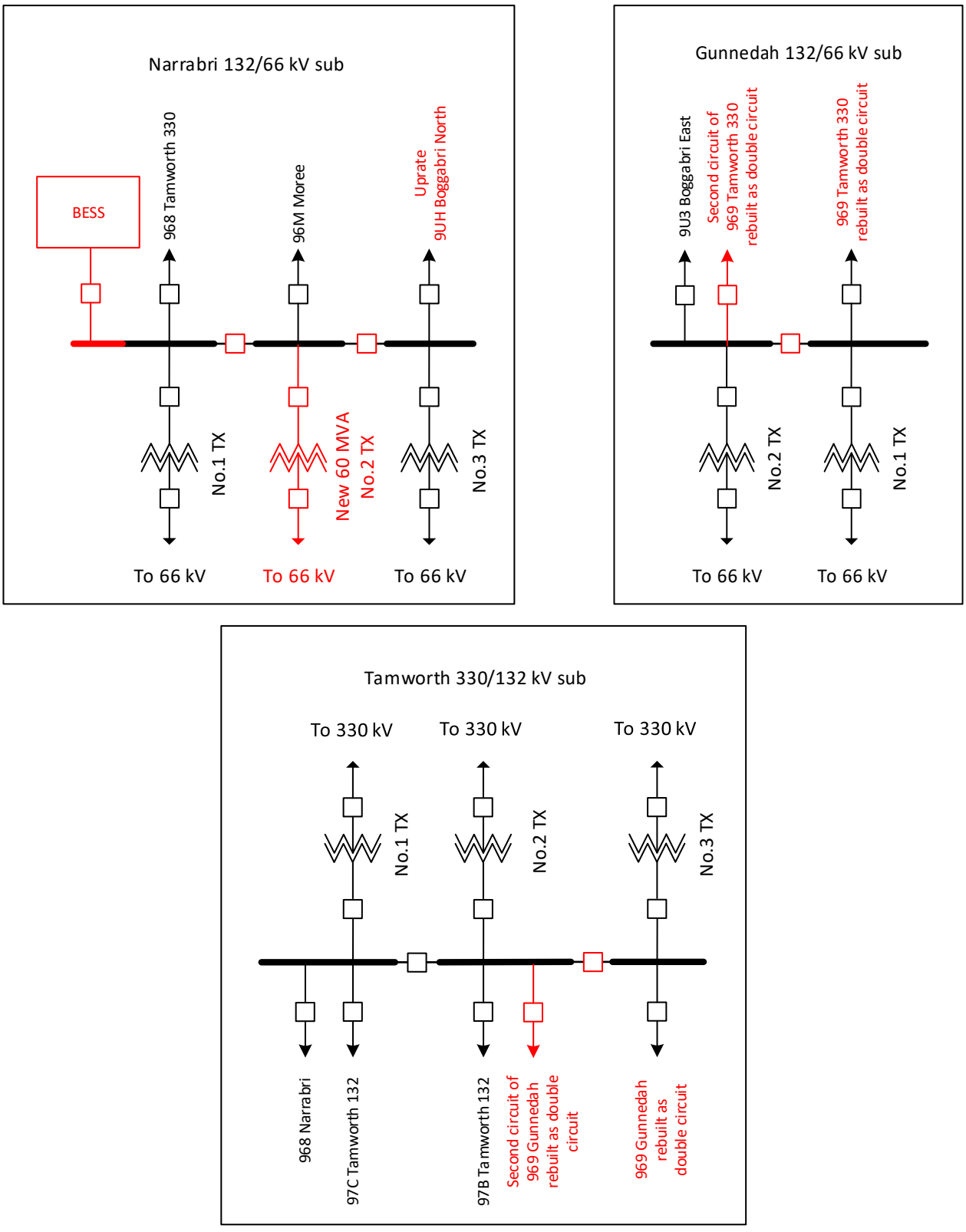
Indicative network diagrams for Option 3A are shown in Figure 3-7.

Figure 3-7: Network diagrams for Option 3A



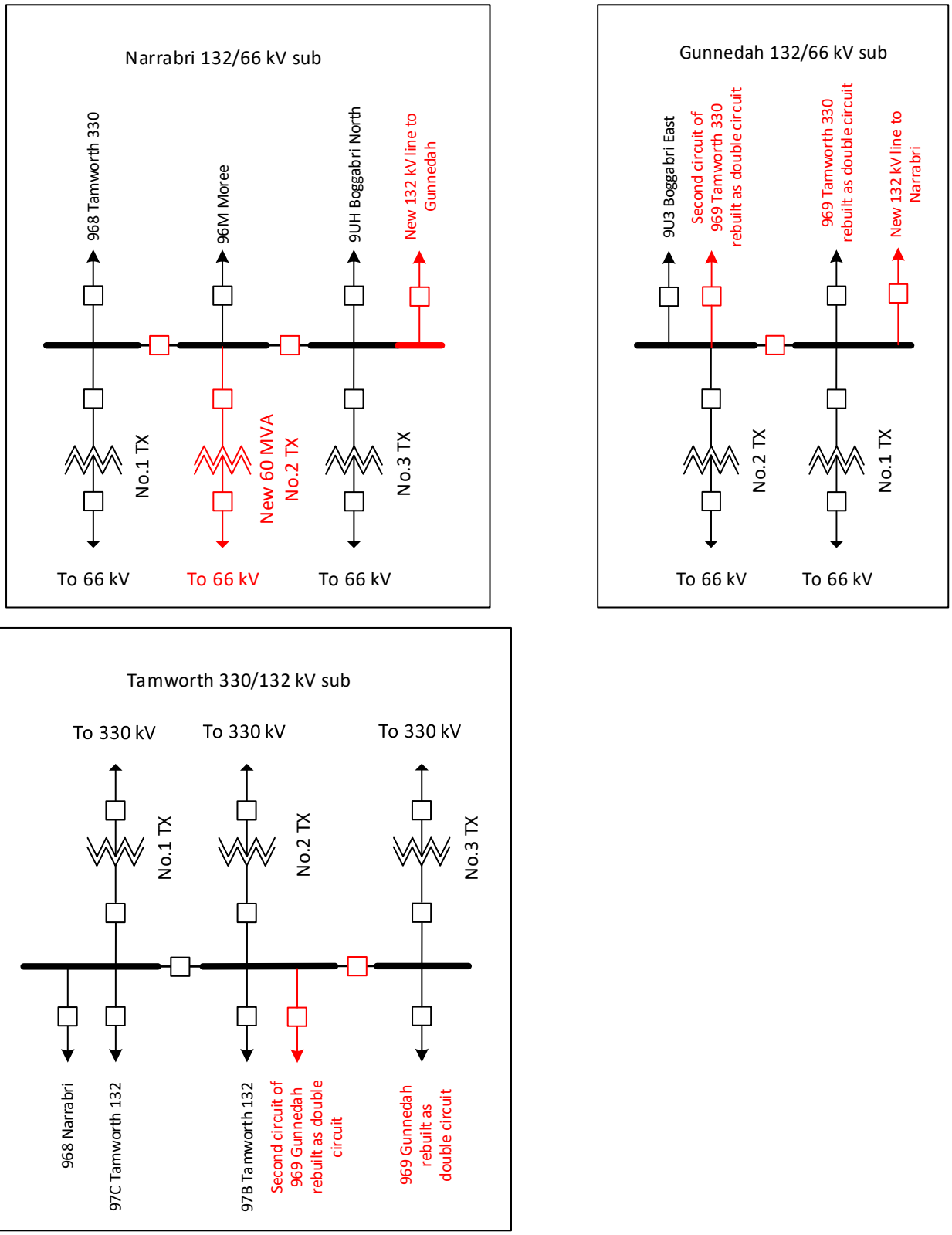
Indicative network diagrams for Option 3B are shown in Figure 3-8 below.

Figure 3-8: Network diagrams for Option 3B



Indicative network diagrams for Option 3C are shown in Figure 3-9 below.

Figure 3-9: Network diagrams for Option 3C



3.5 Option 4 – Connection to the NETI project

This option involves connecting to a potential new private transmission project in the Gunnedah area called the New England Transmission Infrastructure (NETI).[24]

The NETI project is a potential 330 kV transmission line between Tamworth 330/132 kV substation and a new 330 kV substation between Tamworth and Gunnedah to connect up to 1,400 MW of new generation to the main grid network.[25]

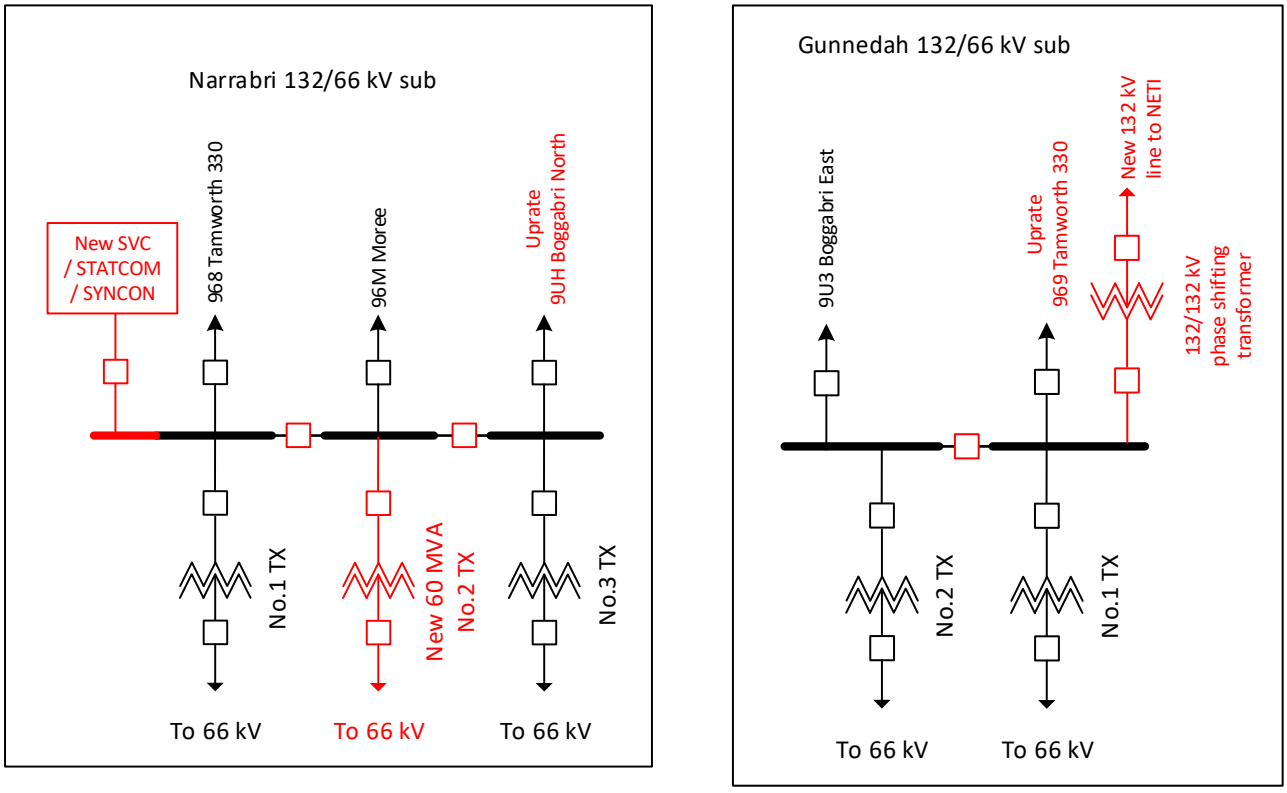
ARENA has provided funding to TransGrid to assess the feasibility of an innovative commercial model to develop the NETI with the aim of unlocking new renewable energy investment in the New England area of NSW. Specifically, the commercial model seeks to directly fund the NETI from renewable energy participants in exchange for firm capacity to connect to the NSW grid.[26] The NETI project is separate to the NSW Government's commitment to develop a New England Renewable Energy Zone (REZ) and is being proposed assuming that the New England REZ goes ahead.

The feasibility of this option is dependent on the NETI project proceeding and an appropriate regulatory pathway to allow such a connection and will be assessed further as part of the PADR.

The scope of the elements for Option 4 is shown in Table 3-1 above.

Indicative network diagrams for Option 4 are shown in Figure 3-10 below.

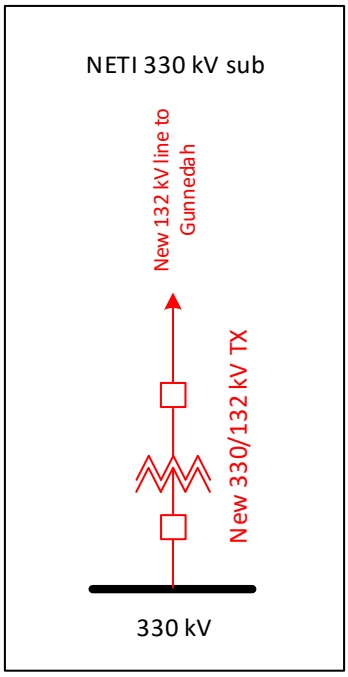
Figure 3-10: Network diagram for Option 4



[24] The NETI project is being developed by TransGrid Services, a related entity in TransGrid.

[25] https://arena.gov.au/projects/transgrid-new-england-renewable-energy-zone/

[26] https://arena.gov.au/projects/transgrid-new-england-renewable-energy-zone/



3.6 Option 5 – Non-network options

TransGrid considers that non-network solutions may be able to form credible options for this RIT-T, either as standalone options or in combination with network options (or components of these options).

While the ultimate assessment of non-network options will depend on responses received to this PSCR, at this stage, TransGrid considers these technologies may include, but are not limited to, the following:

- generation (both embedded and grid-connected); and
- energy storage (bulk or aggregated systems), including:
  - sealed batteries;
  - flow batteries;
  - concentrated solar thermal with storage;
  - compressed air storage; and
  - pumped hydro.
- voluntary curtailment of customer load.

Section 4 and the accompanying EOI provide details on the technical information that proponents of non-network options need to provide in order to enable their option to be considered in this RIT-T.

3.7 Options considered but not progressed

TransGrid also considered whether other options could meet the identified need. Reasons these options were not progressed are summarised in Table 3-2.

Table 3-2: Options considered but not progressed

Option	Reason(s) for not progressing
Capacitor banks/ switched capacitors	Not technically feasible. TransGrid's studies show that due to the expected extensive load growth in the Narrabri and Gunnedah areas, adding a number of additional capacitor banks or switched capacitors in the area is a non-credible solution since step changes in voltages caused by their switching would lead to voltage excursions outside NER requirements.

3.8 No material inter-market network impact is expected

TransGrid considered whether the credible options listed above are expected to have a material inter-regional impact.[27] A 'material inter-network impact' is defined in the NER as:

> *"A material impact on another Transmission Network Service Provider's network, which may include (without limitation): (a) the imposition of power transfer constraints within another Transmission Network Service Provider's network; or (b) an adverse impact on the quality of supply in another Transmission Network Service Provider's network."*

AEMO's suggested screening test to indicate that a transmission augmentation has no material inter-network impact is that it satisfies the following:[28]

- a decrease in power transfer capability between transmission networks or in another Transmission Network Service Provider's (TNSP's) network of no more than the minimum of 3 per cent of the maximum transfer capability and 50 MW
- an increase in power transfer capability between transmission networks or in another TNSP's network of no more than the minimum of 3 per cent of the maximum transfer capability and 50 MW
- an increase in fault level by less than 10 MVA at any substation in another TNSP's network
- the investment does not involve either a series capacitor or modification in the vicinity of an existing series capacitor.

TransGrid considers that each credible option satisfies these conditions as it does not modify any aspect of transmission assets and will only have localised effects around the North West region of NSW. By reference to AEMO's screening criteria, there is no material inter-network impacts associated with any of the credible options considered.

[27] As per clause 5.16.4(b)(6)(ii) of the NER.

[28] Inter-Regional Planning Committee. *"Final Determination: Criteria for Assessing Material Inter-Network Impact of Transmission Augmentations."* Melbourne: Australian Energy Market Operator, 2004. Appendix 2 and 3, available at: https://www.aemo.com.au/-/media/Files/PDF/170-0035-pdf.pdf

4. Technical characteristics for non-network options

This section describes the technical characteristics that a non-network option would need to deliver to address the identified need.

The NER require a PSCR to include characteristics, such as:[29]

- the size of load reduction or additional supply required;
- the location; and
- the operating profile.

While specifying the technical characteristics that non-network options would need to exhibit is difficult for the identified voltage and thermal constraints, since the exact characteristics are dependent on a range of factors unrelated to one another,[30] TransGrid has set out a range of indicative requirements for these solutions.

Specifically, TransGrid considered the variables that drive each of the different components of the identified need (ie, the voltage and thermal constraints), what a non-network option should be able to provide and provided an indicative assessment of when such options must be available. This includes estimating the following for both the voltage constraint and the thermal constraint:

- magnitude of voltage support required (MVAr);
- magnitude of load reduction required (MW);
- expected cumulative exposure per annum (hours);
- frequency per annum; and
- expected duration per event (hours).

While this section summarises these expected requirements, the accompanying EOI provides greater detail and specifies the type and form of information TransGrid is seeking from proponents in order to have their solutions assessed in the PADR. All indicative requirements below are for the central demand forecasts.

TransGrid encourages interested parties to make contact (via written submissions or otherwise) regarding the potential for their non-network solution to satisfy, or contribute to satisfying, the identified need outlined above.

4.1 Overview of the expected requirements

Depending on the load growth in the Narrabri and Gunnedah area, a combined non-network solution of up to 52 MW and up to 50 MVAr will be considered on a cost-benefit basis to address the voltage and thermal constraints.

Possible solutions include (but are not limited to):

- generation (both embedded and grid-connected); and
- energy storage (bulk or aggregated systems), including but not limited to:
  - sealed batteries;

[29] NER clause 5.16.4(b)(3).

[30] Specifically, in the case of voltage control in the North West Slopes region of NSW, the required technical characteristics of non-network options depend on: (1) load forecasts for existing and expected new mining loads in the area; (2) general system demand in the area; and (3) renewable generation in the region (and, in particular, wind generation).

  - flow batteries;
  - concentrated solar thermal with storage;
  - compressed air storage; and
  - pumped hydro.
- voluntary curtailment of customer load.

These solutions will be assessed in the RIT-T economic evaluation on a total cost basis, consistent with the RIT-T Application Guidelines published by the AER.

When provided, these solutions may be owned by the TNSP (TransGrid), the proponent, or a third party that provides the required services to us. Where TransGrid owns the solution, it may lease a portion of the solution (and the operational rights) to provide market services, in accordance with the AER ring fencing guidelines. The provision of any market services must not interfere with the solution's ability to provide the required support services to TransGrid.

Without any investment, the voltage constraint at Narrabri/Gunnedah is expected to bind for approximately 2 to 7 per cent of the year from 2025 to 2029. Similarly, TransGrid expects the thermal limitations in the local area for 3 to 9 per cent of the year between 2025 and 2029 under system normal

4.2 Assisting with the voltage constraint

Fast-acting (dynamic) reactive voltage support can be provided by:

- renewable generation (fast reactive capability of inverters including night-time support); and
- battery systems (fast reactive capability of inverters)

To improve the efficacy of these solutions, plant will need to be located 'electrically close' to the respective locations at which it is required, connected at that voltage, to minimise reactive losses and remain available under credible contingencies of key transmission network elements.

The two tables below set out the expected requirements at both the Gunnedah 132 kV substation and the Narrabri 132 kV substation.

Table 4-1: Expected Gunnedah 132 kV substation dynamic voltage support requirements

Year	Magnitude of voltage support required (MVAr)	Expected cumulative exposure per annum (hours)	Frequency per annum	Expected duration per event (hours)
2025	20	140	74	2
2029	50	578	205	3

Note: The frequency and duration of these requirements have been estimated using historical loads as a proxy.

Table 4-2: Expected Narrabri 132 kV substation dynamic voltage support requirements

Year	Magnitude of voltage support required (MVAr)	Expected cumulative exposure per annum (hours)	Frequency per annum	Expected duration per event (hours)
2029	50	578	205	3

Note: The frequency and duration of these requirements have been estimated using historical loads as a proxy.

In practice, dynamic voltage support will be required immediately (contingency or otherwise) when the voltage drops to or below 90 per cent of the normal voltage, which may occur more frequently in operation. Without

this fast-acting voltage support in place, a rapid decline in voltage may occur leading to voltage collapse (blackouts) in the area. Therefore, this dynamic voltage support needs to be available in anticipation of a voltage disturbance.

4.3 Assisting with the voltage and thermal constraint

Load reductions can be provided by:

> generation;
> energy storage (including battery systems), which inject power into the grid when required; and
> voluntary curtailment of customer load.

The table below sets out the expected load reductions at the Narrabri or Gunnedah 132 kV substations.

Table 4-3: Expected Narrabri or Gunnedah 132 kV substation expected load reductions

Year	Magnitude of load reductions required (MW)	Expected cumulative exposure per annum (hours)	Frequency per annum	Expected duration per event (hours)
2025	29	245	109	2
2027	34	284	123	2.5
2029	52	781	238	3.5

Note: The frequency and duration of these requirements have been estimated using historical loads as a proxy.

In practice, network support may be required at any time the load exceeds the voltage stability limit. Without these load reductions, a rapid decline in voltage may occur following a contingency, leading to voltage collapse (blackouts) in the area. Therefore, this network support needs to be available in anticipation of a voltage disturbance.

For the thermal constraint, network support for the thermal constraint is typically required within 5 minutes of a contingent trip of a line to not exceed its short-term rating.

To improve the efficacy of these solutions, the non-network solution will need to be located at the Narrabri or Gunnedah substations or be supplied by the respective zone substations. Table 4-4 below summarises the downstream Essential Energy zone substations to indicate where load reductions may occur.

Table 4-4: Downstream Essential Energy zone substations supplied by TransGrid

Narrabri Zone Substations	Gunnedah Zone Substations
Brewarrina	Boggabri
Burren Junction	Gunnedah 22kV
Lightning Ridge	Keepit Dam
Merrywinebone	-
Narrabri	-
Walgett	-
Wee Waa	-

5. Materiality of market benefits

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.[31]

The PSCR is required to set out the classes of market benefit that the TNSP considers are not likely to be material for a particular RIT-T assessment.[32]

5.1 Avoided unserved energy is material

TransGrid considers at this stage that changes in involuntary load shedding are expected to be material for the credible options outlined in this PSCR.

Other categories of market benefits prescribed in the NER are not considered material for this RIT-T at this stage, with the exception of option value, as outlined in the sections below.

5.2 Options replacing line 969 would avoid future wood pole replacement costs

Under the base case, TransGrid expects to replace aged wood pole structures on line 969 and 968 in the next five to ten years.

For all options that replace line 969 and/or 968 with a new line, this expenditure is able to be avoided (and so provide an economic benefit). TransGrid is currently assessing condition data (which will inform the associated avoided cost) and expects to include this in the PADR cost benefit assessment.

5.3 Option value will be captured implicitly through the scenario analysis

TransGrid intends to capture the 'option value' associated with each credible option in the PADR by investigating how the timing of the various components is affected by external developments across the scenarios (e.g., new load connecting). This will be captured implicitly in the scenario analysis undertaken, as opposed to undertaking comprehensive real options analysis, which would require a substantial modelling exercise that, at this stage, is not considered proportionate to the level of option value between the options.

5.4 Wholesale electricity market benefits are not material

TransGrid considers at this stage that a number of classes of market benefits are not expected to be material in the RIT-T assessment, and so do not need to be estimated, since the credible options are not expected to have a material impact on the wholesale electricity market.

While some of the credible network options set out in this PSCR will provide additional network capacity to the North West Slopes system, TransGrid does not consider there to be material wholesale market benefits associated with this. Specifically, while this additional capacity may affect the investment decisions of future local renewable generators on the 132 kV network, downstream 330 kV network constraints outside of this RIT-T (particularly south of Tamworth) mean that any new generation is not expected to displace the output of

[31] NER clause 5.16.1(c)(6).
[32] NER clause 5.16.4(b)(6)(iii).

generation elsewhere and so there is not expected to be any material wider wholesale market impacts between the options and the base case.

Similarly, none of the options are expected to add to, or takeaway from, any wholesale market benefits from future expansions of QNI over the longer term (ie, QNI Medium and Large interconnector upgrades referred to in the ISP). These future upgrades of QNI are expected to be 500 kV and will not tie into the 132 kV network in the North West Slopes (despite likely passing nearby).

As a consequence, the credible options considered in this PSCR do not address network constraints between competing generators and so will not have an impact on generation dispatch outcomes and the wholesale electricity market. Therefore, TransGrid 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 penalties.

In addition, there is not expected to be any material difference in transmission losses between options.

6. Overview of the assessment approach

As outlined in section 3.1, all costs and benefits considered will be measured against a base case where the longer-term constraints associated with load growth in the North West Slopes area are unresolved and there is expected to be significant interruption of supply to loads in the area under normal and contingency conditions due to voltage/thermal limitation and/or voltage collapse in the local supply network.

The RIT-T analysis will consider a 20-year assessment period from 2020-21 to 2039-40. TransGrid considers that a 20-year period reflects the period for which demand forecasts for the area are available. It also 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.

Where the capital components of the credible options have asset lives extending beyond the end of the assessment period, the NPV modelling will include 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 will be 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.

A real, pre-tax discount rate of 5.90 per cent is proposed to be adopted as the central assumption for the NPV analysis presented in this PADR, consistent with the assumptions adopted in the 2020 ISP. The RIT-T requires that sensitivity testing be conducted on the discount rate and that the regulated weighted average cost of capital (WACC) be used as the lower bound. TransGrid therefore proposes to test the sensitivity of the results to a lower bound discount rate of 2.23 per cent,[33] and an upper bound discount rate of 7.90 per cent (i.e., consistent with the latest AEMO Input Assumptions and Scenarios report).

6.1 Approach to estimating project costs

The initial capital cost estimates presented in this PSCR have been developed 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 PSCR and further detailed costing with the objective to achieve costs that are estimated to be within +/- 25 per cent of the actual cost.

Initial routine operating and maintenance cost estimates have been estimated at two per cent of the capital expenditure. These costs will also be refined during the PADR stage to reflect what would be incurred under each option.

6.2 Three different scenarios will be modelled to address uncertainty

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.

[33] 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/directlink-determination-2020-25

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 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.

A key expected driver of the net market benefits is likely to be the VCR. TransGrid is proposing to use the VCR estimates developed and consulted on by the AER in the PADR assessment.[34]

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%
Load forecasts	Central demand (as shown in section 2.3.1 of this PSCR)	Low demand (as shown in section 2.3.1 of this PSCR)	High demand (as shown in section 2.3.1 of this PSCR)
New renewable generation in the area	In-service and committed generators from Table 2-1.	All in-service, committed and advanced generators from Table 2-1.	In-service and committed generators from Table 2-1.
VCR	Load-weighted VCR based on the AER estimates and the different load types affected	30 per cent lower VCR in accordance with the AER's stated confidence level[35]	30 per cent higher VCR in accordance with the AER's stated confidence level[36]
Discount rate	5.90%	7.90%	2.23%

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.

[34] AER, *Values of Customer Reliability, Final report on VCR values*, December 2019.

[35] AER, *Widespread and Long Duration Outages – Values of Customer Reliability Final Conclusions*, September 2020, p. 8.

[36] AER, *Widespread and Long Duration Outages – Values of Customer Reliability Final Conclusions*, September 2020, p. 8.

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 158.

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
	(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 & 5